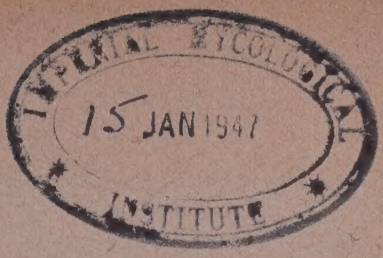
A29

The Kent Incorporated Society for Promoting Experiments in Horticulture



ANNUAL REPORT

(THIRTY-THIRD YEAR)

1945

EAST MALLING RESEARCH STATION

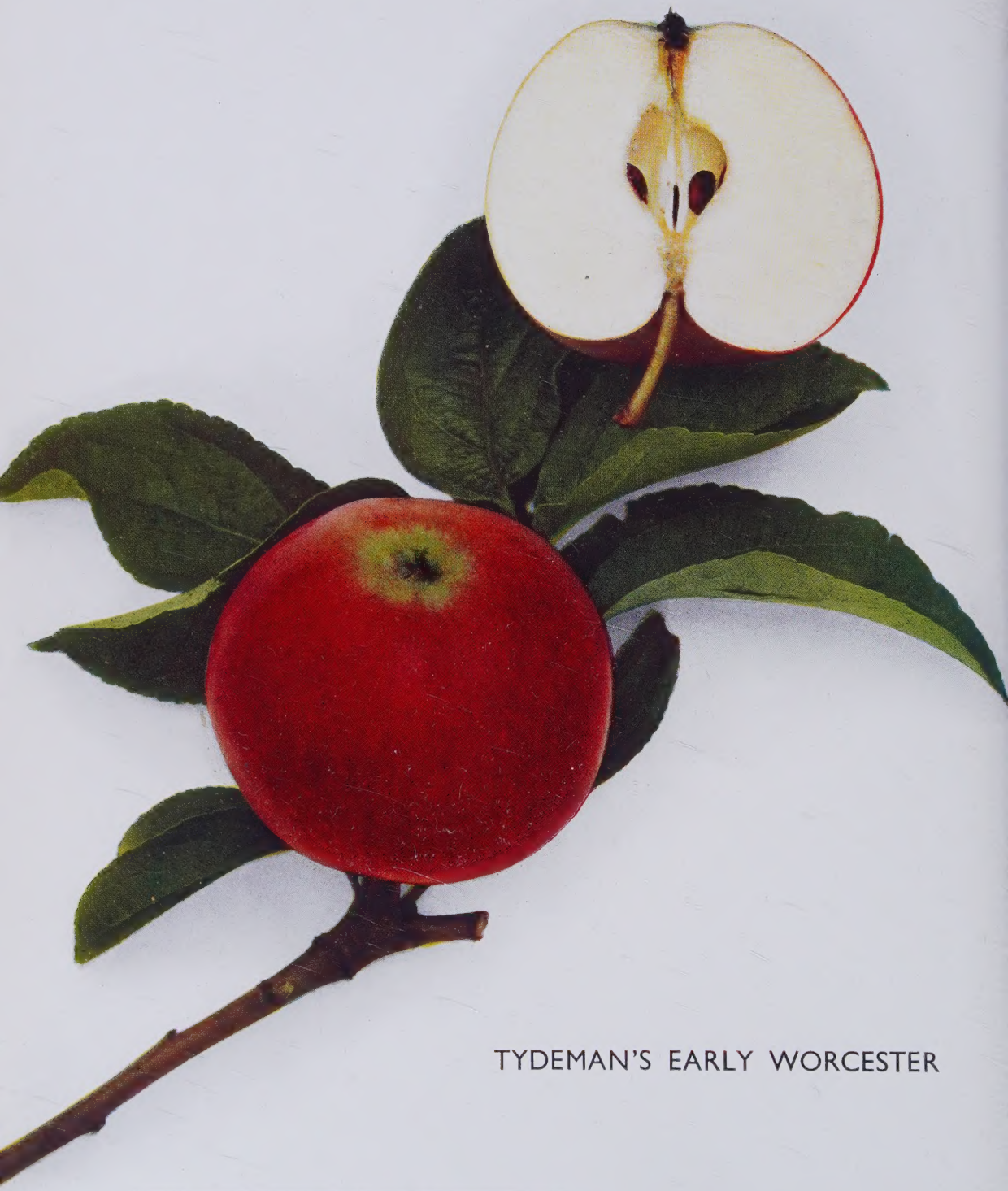
Near MAIDSTONE

KENT

1st January, 1945 to 31st December, 1945

Price 10/- post free Great Britain only

Published December, 1946



TYDEMAN'S EARLY WORCESTER

A contribution from the Worshipful Company of Fruiterers towards the cost of this plate is gratefully acknowleged.

THE KENT INCORPORATED SOCIETY
FOR PROMOTING EXPERIMENTS IN
HORTICULTURE

ANNUAL REPORT

(THIRTY-THIRD YEAR)

1945

EAST MALLING RESEARCH STATION

Near MAIDSTONE

KENT

1st January, 1945, to 31st December, 1945

Published December, 1946

The correct abbreviation of this issue of this Report is:—
Rep. E. Malling Res. Sta. for 1945 (1946).

POMOLOGY—*continued.* PAGE

Progress Report on the Walnut Variety Collection at East Malling. ELIZABETH M. GLENN and A. W. WITT 70

Cracking of Apples. A. P. PRESTON 75

Weather Conditions during 1945. H. M. TYDEMAN and A. P. PRESTON 76

PLANT PHYSIOLOGY

Propagation of Fruit Tree Rootstocks by Stem Cuttings. IV. Effects of Soil Conditions on Habit of Growth in Myrobolan B. M. C. VYVYAN and R. J. GARNER 79

BIOCHEMISTRY

Mineral Deficiencies in Agricultural and Horticultural Crops II. W. A. ROACH 83

Physiological Effects of Trace Elements. B. D. BOLAS 89

ENTOMOLOGY

Notes on Some Interesting Insects observed in 1945. A. M. MASSEE 90

HOPS

Propagation Trials with Hops. II. Preliminary Trials in Propagation by Soft-wood Cuttings. F. H. BEARD and DOROTHY J. WILSON 96

Propagation Trials with Hops. III. A Comparison of the Performance of Cuttings made from Runners, Layers and "Straps". F. H. BEARD 104

Observations on the Incidence of Mould (*Sphaerotheca Humuli*) on the New Seedling Hops at East Malling in 1945. F. H. BEARD 107

Section IV

BULLETINS FOR FRUITGROWERS

The Dessert Apple Plantation of Tomorrow. T. N. HOBLYN 115

Two New Apple Varieties Bred at East Malling. H. M. TYDEMAN 121

Dwarf Pyramid Culture. LESLIE R. E. MARTIN 123

The Rootstock Malling Crab C. R. J. GARNER 126

The Recognition of Some Apple and Plum Rootstocks in the Nursery. R. J. GARNER .. 130

Plant Myrobolan Cuttings Closer to Improve Their Shape. R. J. GARNER 131

Malling Promise Raspberry. N. H. GRUBB 133

Bacterial Canker and Leaf Spot of Plum and Cherry. A Summary of Present Knowledge of Control Measures in Britain. M. H. MOORE 134

General Considerations in the Use of D.D.T. against Fruit Pests. H. SHAW 138

The Apple Blossom Weevil and Its Control. G. H. L. DICKER 140

Overwintering of Woolly Aphid Parasite (*Aphelinus mali* Hald.) in Low Temperature Apple Stores. A. M. MASSEE 142

INDEX 145

GOVERNING MEMBERS OF THE SOCIETY

Appointed by the Ministry of Agriculture :

Sir Frederick W. Keeble, Kt., C.B.E., Sc.D., F.R.S., Cedron House, Fowey, Cornwall.

Appointed by the Kent County Council :

Sir Edward Hardy, Boughton Court, Ashford, Kent.
T. D. Harris, Esq., O.B.E., Tudeley Hall, Tonbridge, Kent.
Major F. D. Thomas, Loose Court, Loose, near Maidstone, Kent.

Appointed by the Surrey County Council :

S. S. Boorman, Esq., " Birchley ", West Clandon, Surrey.

Appointed by the East Sussex County Council :

E. S. Attrell, Esq., Warren Fruit Farm, North Common, Chailey, Sussex.

Appointed by the West Sussex County Council :

General Sir Ivor Maxse, K.C.B., C.V.O., D.S.O., Little Bognor, Fittleworth, Sussex.

Appointed by the Council of the Senate of the University of Cambridge :

Professor F. T. Brooks, M.A., F.R.S., Botany School, Cambridge.

Appointed by the Senate of the University of London :

Professor Wm. Brown, D.Sc., F.R.S., Imperial College of Science and Technology, South Kensington, London, S.W.7.

Appointed by the University of Bristol :

Professor T. Wallace, M.C., D.Sc., A.I.C., The Research Station, Long Ashton, near Bristol.

Appointed by the Governing Body of the Imperial College of Science and Technology :

Professor V. H. Blackman, Sc.D., F.R.S., Imperial College of Science and Technology, South Kensington, London, S.W.7.

Appointed by the Council of the Royal Society :

Sir Edward J. Salisbury, C.B.E., D.Sc., F.R.S., 47 Kew Green, Kew, Surrey. (*Retired June*, 1945.)
Dr. E. J. Maskell, F.R.S., The Botany School, Cambridge. (*Appointed June*, 1945.)

Appointed by the Governors of Wye College, Kent :

A. Amos, Esq., M.A., Spring Grove Farm, Wye, Kent.
D. Skilbeck, Esq., M.A., Wye College, Wye, Kent. (*Appointed July*, 1945.)
V. R. S. Vickers, Esq., Wye College, Wye, Kent. (*Retired July*, 1945.)

Appointed by the Research and Advisory Committee of Wye College, Kent :

S. G. Jary, Esq., B.A., Dip.Agric.(Cantab.), Wye College, Wye, Kent.

Appointed by the Governors of John Innes Horticultural Institution :

M. B. Crane, Esq., John Innes Horticultural Institution, Mostyn Road, Merton Park, London, S.W.19.

Appointed by the Council of the Royal Horticultural Society :

F. A. Secrett, Esq., F.L.S., V.M.H., Bell Farm, Felcott Road, Walton-on-Thames, Surrey.

Appointed by the Council of the Institute of Brewing :

Walter Scott, Esq., J.P., Messrs. Ansell's Brewery, Ltd., Aston, Birmingham 6.

Appointed by the Research Fund Committee of the Institute of Brewing :

G. T. Cook, Esq., Lulworth, Queen's Avenue, Maidstone, Kent.

Appointed by the National Farmers' Union (Central Council, London) :

J. S. Chivers, Esq., Messrs. Chivers & Sons, Ltd., Histon, Cambridge. (*Retired July*, 1945.)
J. E. Sandall, Esq., J.P., Beechwood, Clarkson Avenue, Wisbech, Cambridge.
G. Tuker, Esq., Thorn Cottage, Danbury, Essex. (*Appointed July*, 1945.)

Appointed by the National Farmers' Union (Kent Branch) :

W. Alexander, Esq., Home Farm, Eynsford, Kent. (*Appointed July*, 1945.)
Alfred Day, Esq., O.B.E., J.P., Great Tong Farm, Headcorn, Kent.
S. R. Dixon, Esq., J.P., Cambridge, Teynham, Sittingbourne, Kent.
W. T. Edmonds, Esq., Allington Farm, Maidstone, Kent.
E. W. Gaskain, Esq., Rhode Court, Selling, near Faversham, Kent. (*Appointed July*, 1945.)
E. Bruce Gibson, Esq., Lumbersland, Birchwood, Wilmington, Dartford, Kent.
Sir Amberson B. Marten, Kt., M.A., LL.D., Gedges, Matfield, near Tonbridge, Kent. (*Retired July*, 1945.)
A. T. Miller, Esq., Wested Farm, Swanley, Kent. (*Deceased August*, 1945.)
C. T. Miller, Esq., Wested Farm, Swanley, Kent. (*Appointed July*, 1945.)
D. J. Moor, Esq., Nichol Farm, Teynham, Sittingbourne, Kent.

J. W. S. MOUNT, Esq., Little Barton, Canterbury, Kent.
T. NEAME, Esq., Macknade, Faversham, Kent.
J. A. RAYNHAM, Esq., Dairy Farm, Marden, Kent. (*Retired July*, 1945.)
J. M. ROBERTSON, Esq., Beluncle, Hoo, Rochester, Kent. (*Retired July*, 1945.)
J. F. TOWNER, Esq., Salts Farm, Loose, near Maidstone, Kent.
W. RODNEY WILSON, Esq., Mount Ephraim, Cranbrook, Kent. (*Appointed July*, 1945.)

Appointed by the Council of the Horticultural Trades' Association :

L. J. COOK, Esq., 7 Drapers Road, Enfield, Middlesex.

Appointed by the Associate Members of East Malling Research Station :

STUART MACDONALD, Esq., Little Baddow Hall, near Chelmsford, Essex. (*Retired August*, 1945.)
W. P. SEABROOK, Esq., Branwoods, Great Baddow, Chelmsford, Essex. (*Appointed August*, 1945.)
Captain R. WELLINGTON, M.C., Colescus, Gorran Haven, Cornwall.
R. D. WICKHAM, Esq., Gate House Farm, Brenchley, Kent. (*Appointed August*, 1945.)

Appointed by East Malling Research Station :

R. G. HATTON, Esq., C.B.E., M.A.(Oxon.), D.Sc.(Lond.), V.M.H., F.R.S.

Appointed by the Staff Council of East Malling Research Station :

H. SHAW, Esq., M.Sc.Tech., Ph.D.(Manc.).

MEMBERS OF THE EXECUTIVE COMMITTEE

(Governing Members elected at the General Meeting, September, 1945)

ARTHUR AMOS, Esq., M.A.
Professor V. H. BLACKMAN, Sc.D., F.R.S. (Vice-Chairman).
Professor F. T. BROOKS, M.A., F.R.S.
Professor WM. BROWN, D.Sc., F.R.S.
G. T. COOK, Esq.
L. J. COOK, Esq.
M. B. CRANE, Esq.
ALFRED DAY, Esq., O.B.E., J.P.
S. R. DIXON, Esq.
W. T. EDMONDS, Esq.
E. W. GASKAIN, Esq.
Sir EDWARD HARDY.
General Sir IVOR MAXSE, K.C.B., C.V.O., D.S.O.
J. W. S. MOUNT, Esq.
T. NEAME, Esq. (Chairman).
J. E. SANDALL, Esq.
G. E. TUKER, Esq.
Professor T. WALLACE, M.C., D.Sc., A.I.C.
Captain R. WELLINGTON, M.C.

The Director :

R. G. HATTON, Esq., C.B.E., M.A.(Oxon.), D.Sc.(Lond.), V.M.H., F.R.S.

The Representative of the Staff Council :

H. SHAW, Esq., M.Sc.Tech., Ph.D.(Manc.).

Co-opted Members :

J. S. CHIVERS, Esq., Messrs. Chivers & Sons, Ltd., Histon, Cambridge.
Sir EDWARD SALISBURY, C.B.E., D.Sc., F.R.S., 49 Kew Green, Kew, Surrey.
Lieut.-Colonel Sir ALBERT STERN, K.B.E., C.M.G., Barham Court, Maidstone, Kent.
H. V. TAYLOR, Esq., O.B.E., D.Sc.(Lond.), A.R.C.S., Ministry of Agriculture.

STAFF (April, 1946)

Director : RONALD G. HATTON,* C.B.E., M.A.(Oxon.), D.Sc.(Lond.), V.M.H., F.R.S.
Assistant to Director : T. N. HOBLYN,* Hort.Dip.(Wye).
Pomology : R. G. HATTON.*
W. S. ROGERS, M.A.(Cantab.), Ph.D.(Lond.), Dip.Hort.(Cantab.), A.Inst.P.
N. H. GRUBB, M.S.A.(Cornell).
Miss A. B. BEAKBANE, Ph.D.(Lond.), N.D.H.
R. J. GARNER, N.D.H., Dip.Hort.Sci.(Reading).
D. W. P. GREENHAM, M.A.(Cantab.). (*Appointed April*, 1946.)
Th. RAPTOPOULOS, Ph.D.(Lond.), *Research Assistant.*† (*Resigned October*, 1945.)
H. M. TYDEMAN, *Plant Breeding.*
A. W. WITT, N.D.H., *Consultant, Walnuts.*
A. P. PRESTON, N.D.H., *Field Pomologist.*
C. A. WOOD, Ph.D.(Wales). *Small Fruits,*† *Scottish Raspberry Investigations.* (*Appointed April*, 1946.)
Miss E. M. GLENN, B.Sc.(Lond.), *Research Assistant.*
Miss E. C. THOMPSON, *Research Assistant.*
Miss H. M. HUGHES, B.Sc.(Lond.), Dip.Hort.(Swanley). (*Resigned July*, 1945.)
Miss J. M. BUTTFIELD, N.D.H., Dip.Hort.(Swanley), *Special Assistant, Nuclear Stocks Scheme.* (*Resigned June*, 1945.)
Miss B. G. MOSSE, B.Sc.(Lond.), Dip.Hort.(Swanley), *Research Assistant,*† *Histological Investigations.*
Miss I. MODLIBOWSKA, Ph.D.(Lond.). *Research Assistant.* (*Appointed July*, 1945.)
Miss L. R. E. MARTIN, B.Sc.(Lond.), Hort.Dip.(Studley), *part-time.* (*Transferred from Plant Protective Chemistry Section, September*, 1945.)

* Recognized Teacher of the University of London.
† Appointed under special grant from Agricultural Research Council.

Lab. and Field Assistants :
C. H. W. SLATER. (*On Active Service.*)
Miss F. BACON. (*Appointed October*, 1945.)
C. F. MILLS. (*Resigned August*, 1945.)
G. L. KING. (*Appointed August*, 1945.)
Miss E. C. M. ASHDOWN.
Miss F. M. HODGES.
Miss O. ROBINSON.
Mrs. M. E. J. BINGHAM. (*Resigned November*, 1945.)
Miss D. E. A. YATES.
G. WELLER. *Workshop and Recorder.*

Hops : F. H. BEARD, Hort.Dip.(Wye).
Miss D. J. WILSON, B.Sc.(Reading), *Assistant,† Hop Propagation.*

Statistics : T. N. HOBLYN.*
S. C. PEARCE, B.Sc.(Lond.).
Miss E. M. GLENN, B.Sc.(Lond.). (*Part-time—Records.*)
Miss J. M. S. THOM. *Computor.*

Plant Physiology : M. C. VYVYAN,* M.A.(Cantab.), D.Sc.(Lond.).
Laboratory Assistants :
G. F. TROWELL. (*On Active Service.*)
Miss M. R. RAWES. (*Appointed September*, 1945.)
A. G. LLOYD. (*Appointed August*, 1945.)
Member of Staff of the Imperial College of Science working in collaboration with Physiology Section :
E. S. J. HATCHER, Ph.D.(Bristol). (*Appointed October*, 1945.)

Biochemistry : W. A. ROACH,* D.Sc.(Lond.), A.R.C.S., D.I.C., A.R.I.C.
Mrs. W. O. ROBERTS, B.Sc.(Wales). (*Seconded for War Service from the Education Committee of the City of Liverpool.*)
J. P. R. RICHES, M.A.(Cantab.). (*Resigned October*, 1945.)
S. G. THOMPSON, M.C., M.A.(Oxon.).
C. BARCLAY, M.A., Dip.Agric.(Cantab.). *Field Officer.†*
A. C. MASON, B.Sc.(Lond.), *Physical Chemist.†* (*Appointed February*, 1946.)
F. H. VANSTONE, Ph.D.(Wales), *Physicist.†* (*Appointed April*, 1946.)
Miss H. M. HOLMES, Dip.Hort.(Swanley), *Assistant Field Officer.†*
Mrs. A. M. HOUGH, B.Sc.(Liv.), *Assistant Field Officer.†*
Special Assistant : Miss M. E. BUNYARD, A.R.R.C.
Laboratory Assistants :
Miss E. M. PARKER, B.Sc.(Lond.). (*Resigned October*, 1945.)
Miss E. M. FORD. (*Resigned October*, 1945.)
Miss D. F. E. MARTIN.
Mrs. C. KING.
Miss C. C. MACNAMARA.
Miss B. M. KIDWELL.
J. A. H. RICHARDS. (*Appointed October*, 1945.)

Members of the Staff of the Imperial College of Science and Technology working in collaboration with the Biochemistry Section:
B. D. BOLAS,* D.Sc.(Lond.), D.I.C.
D. W. GOODALL, Ph.D.(Lond.), D.I.C.
Laboratory Assistant :
J. H. LAVENDER.

Plant Pathology : R. V. HARRIS,* D.Sc.(Lond.), A.R.C.S., D.I.C.
H. WORMALD, D.Sc.(Lond.), A.R.C.S., D.I.C. (*Transferred to the Imperial Bureau of Fruit Production, October*, 1945.)
M. H. MOORE, M.Sc., Dip.Hort.Sci.(Reading). *Plant Pathologist.*
W. G. KEYWORTH, Ph.D.(Lond.), A.R.C.S., D.I.C. *Plant Pathologist.*
I. W. PRENTICE, Ph.D.(Glasgow). *Virologist.*
P. C. R. WEBB, M.Sc.(Lond.), *Mycologist and Bacteriologist.* (*Appointed January*, 1946.)
I. ISAAC, B.Sc.(Wales), Ph.D.(Cantab.). *Assistant,† Hop Diseases.* (*Resigned October*, 1945.)
Miss M. P. ENGLISH, M.Sc.(Lond.). *Research Assistant attached to Plant Protective Chemistry.* (*Resigned November*, 1945.)
Miss M. BENNETT, B.Sc.(Lond.), Dip.Hort.(Swanley). *Research Assistant, Field Trials ; also attached Entomology and Plant Protective Chemistry.*
Miss M. M. HITCHCOCK, B.Sc.(Reading). *Research Assistant, Hop Diseases.*
Miss J. L. SMITH, B.Sc.(Glasgow). *Research Assistant, Laboratory Experiments.* (*Appointed January*, 1946.)
D. S. KIRKHAM, B.Sc.(Lond.). *Research Assistant attached to Plant Protective Chemistry.* (*Appointed May*, 1946.)
Laboratory Assistants :
Miss B. I. FLEET.
Miss F. J. NEWING. *Virus Diseases.*
D. N. ASHBY. (*Appointed February*, 1946.)

Entomology : A. M. MASSEE,* D.Sc.(Lond.), F.R.E.S.
G. H. L. DICKER, Ph.D.(Lond.), A.R.C.S.
M. D. AUSTIN, F.R.E.S. (*Red Spider Investigations in Essex.*)†
E. T. BURTT, M.A., Ph.D.(Cantab.). *Research Assistant,† Red Spider Investigations in Essex.* (*Resigned October*, 1945.)
R. B. SIMS, M.A.(Cantab.). *Research Assistant,† Red Spider Investigations in Essex.* (*Appointed September*, 1945.)
R. G. DAVIES, B.Sc.(Lond.). *Research Assistant attached to Plant Protective Chemistry.* (*Appointed April*, 1946.)
R. S. PITCHER, B.Sc.(Lond.). *Research Assistant,† Raspberry Cane Midge.* (*Appointed April*, 1946.)
Laboratory Assistants : F. CRONK.
E. F. SOUTER. (*On Military Service, November*, 1945.)
J. LUCAS.

* Recognized Teacher of the University of London.
† Appointed under special grant from Agricultural Research Council.

Plant Protective Chemistry : H. SHAW, M.Sc.Tech., Ph.D.(Manc.).
J. K. EATON, B.Sc.(Wales), M.Sc.Tech.(Manc.), Ph.D.(Lond.).
Miss L. R. E. MARTIN, B.Sc.(Lond.), Hort.Dip.(Studley). *Assistant Biologist.* (*Transferred to Pomology Section, September,* 1945.)
For Biological Assistants, see D. S. KIRKHAM, *Plant Pathology, and* R. G. DAVIES, *Entomology Sections.*
Recorders and Laboratory Assistants :
R. G. GAMBRILL, *Recorder.* (*On Active Service.*)
D. A. MITHEN. (*On Active Service.*)
Miss A. J. COLLINGS. (*Resigned December,* 1945.)
J. T. GREAVES, B.A.(Oxon.)
Miss M. F. PALMER. (*Resigned July,* 1945.)
S. P. SIMMONDS. (*Appointed November,* 1945.)
Scottish Raspberry Investigations : Headquarters—University College, Dundee.
C. H. CADMAN, B.Sc.(Liv.), Ph.D.(Edin.). *Plant Pathologist.*†
C. A. WOOD, Ph.D.(Wales). *Pomologist.*† (*Appointed April,* 1946.)
A. R. HILL, B.Sc.(St. Andrews). *Entomologist.*† (*Appointed April,* 1946.)
Field and Laboratory Assistants :
Miss E. C. REOCH. (*Appointed May,* 1945.)
J. P. VALENTINE. (*Appointed March,* 1946.)
Technical Section : H. B. S. MONTGOMERY, B.A.(Dublin), Ph.D.(Lond.), D.I.C.
B. F. G. LEVY, B.A.(Cantab.), Hort. Cert.(Reading). (*Returned from Active Service January* 1946.)
A. C. PAINTER, O.B.E. (*Returned from Active Service and appointed to Technical Section, January,* 1946.)
Miss L. R. E. MARTIN, B.Sc.(Lond.), Hort.Dip.(Studley), *part-time.* (*Transferred from Plant Protective Chemistry Section, September,* 1945.)
Advisory Officer in Commercial Fruit Growing to the Kent Education Committee stationed at East Malling Research Station : W. G. KENT, N.D.H.
Farm Supervisor : F. H. VILLIERS, M.Sc.Agric. (Reading), N.D.A. (*Appointed October,* 1945).
Assistant Plantation Officer : Miss B. F. SEYMOUR.
Experimental Nurseries : D. H. HAMMOND.
Experimental Greenhouses : A. TIDY.
Miss E. K. JOYCE.
Meteorological Records : A. P. PRESTON.
Librarian : Vacant.
Photographer : Vacant.
Lab. Steward : R. G. GAMBRILL. (*On Active Service.*)

† Appointed under special grant from Agricultural Research Council.

ADMINISTRATION.

Secretary : C. T. ROYLE, M.C.
Book-keeper : P. R. WOOD.
Farm Clerk : A. J. SPILLER.
Director's Personal Secretary : Miss L. E. ALEXANDER (*Resigned July,* 1945).
Miss L. M. READ (*Appointed September,* 1945).
Clerical Staff : Miss J. M. COY, Miss G. O. ARDAGH, Miss J. D. MARTIN (*On Active Service*), Miss M. G. ARNUP, Mrs. V. E. DUREY (*part-time, Resigned March,* 1946), Miss L. M. GODDEN, Mrs. Y. GRAY (*Resigned September,* 1945), Miss G. M. MITCHELL, Miss P. RAYFIELD, Miss M. M. ACOTT, Miss M. E. EMM (*Appointed August,* 1945), Miss Y. J. CHITTENDEN (*Appointed August,* 1945), Miss J. M. PARSONS (*Appointed December,* 1945), Miss I. I. THOMPSON (*Appointed January,* 1946).

VISITORS.

Visits may be paid by appointment on any day from Monday to Friday.

The office of the Technical Section has been moved from Bradbourne House to the Research Laboratories, and all visitors wishing to see the work of the Station should go to the Enquiry Office there. *It is most important that an appointment is made beforehand.* The Administrative Offices are still at Bradbourne House.

Visitors coming by road should take the turning to East Malling, opposite " The Bull ", Larkfield, on the main London-Maidstone Road. The entrance gate to the Research Station is on the left, opposite the " King and Queen " in East Malling.

Bus Service : FROM MAIDSTONE by the Maidstone and District Motor Services Limited, every 20 minutes from Maidstone to East Malling.
Passenger Station : EAST MALLING HALT (Southern Railway).
Goods Station : AYLESFORD (Southern Railway).
Correspondence : All correspondence should be addressed to the East Malling Research Station, near Maidstone, Kent.
Telephone : Aylesford 7294 (2 lines). *Telegrams :* Research, East Malling.

THE IMPERIAL BUREAU OF HORTICULTURE AND PLANTATION CROPS

Accommodated at Bradbourne, the Administrative Headquarters of the East Malling Research Station.

STAFF.

Director : D. AKENHEAD, M.A. (Oxon.), B.Sc.Agric.(Lond.).
Consultant Director : RONALD G. HATTON, C.B.E., M.A.(Oxon.), D.Sc.(Lond.), V.M.H., F.R.S.
Assistants : G. ST. CLAIR FEILDEN, B.A.(Oxon.) (*Retired July,* 1945).
V. H. GOLDSCHMIDT, Ph.D.
H. WORMALD, D.Sc.(Lond.), A.R.C.S., D.I.C. (*Appointed October,* 1945).
Clerical Staff : Miss M. B. ROGERS, Miss M. M. DURLING (*On Active Service*), Mrs. B. AKENHEAD, B.Sc.Hort. (Lond.) (*Resigned September,* 1945), Miss M. A. CROUCHER (*Appointed October,* 1945).

FOREWORD

ALMOST another twelve months have gone by since the ending of the year 1945—a year packed with activity for the majority of our Staff. It is not perhaps always realized how much has been expected of the Staff of a Research Institute in recent years, that is not in itself research. A glance through the Supplementary Annual Report, issued to our Members earlier in the present year, gives some idea of the variety of these activities. Quiet and freedom from interruption are necessary for the preparation of Research Reports and Bulletins and it is therefore not surprising that there has been some delay under present circumstances.

As Sections complete their postwar re-organization, recently appointed members of the Research Staff settle down and the National Agricultural Advisory Service gradually eases the load of advisory work, we hope to return to the normal practice of issuing our Annual Report before midsummer. In the meantime Members will find several reports of up-to-date interest in the present issue.

Paper restrictions have forced us to crowd as much as possible into comparatively few pages during the war years. For the first time since the 1938 Report we are now able to relax a little and we hope this year the Report will be easier to read. The return to the practice of printing illustrations on art paper will be particularly welcome.

We should like to acknowledge the assistance of the Worshipful Company of Fruiterers, which has enabled us to include a colour plate of Tydeman's Early Worcester apple, as the frontispiece.

As last year, Mr. Hoblyn has been responsible for editing Sections I, II and III, while Dr. Montgomery has edited the Bulletins for Fruitgrowers in Section IV.

R.G.H.

November, 1946.

Section I

THE EXPERIMENTAL FARM

Edited by T. N. HOBLYN, with contributions from F. H. BEARD, D. H. HAMMOND, A. P. PRESTON and F. H. VILLIERS

It would not be fitting to render an account of the year 1945 on the experimental farm without reference to the untimely passing of Mr. J. Amos, for so long Farm Manager. A full account of his valued service to the Station was given in last year's Report ; it is sufficient to record here that in his time the farm grew from 23 to 360 acres and that he has left behind him a tradition of good farming allied to the exacting needs of research that will not readily be forgotten.

After Mr. Amos's death in March until the appointment of Mr. F. H. Villiers as Farm Supervisor in October, the management of the farm was carried on by the Director, assisted by those in charge of the fruit, arable, nursery and hop sections of the work. The good team work during this time carried us through a season in which many difficulties had to be surmounted.

Our grower Members will remember the autumn and winter 1944-5 as one of the most adverse in their experience. In face of an acute labour shortage, an exceptionally wet autumn held up all farm operations. This situation was not aided by a cold January, during which all outside work was reduced to a standstill. As will be seen, these conditions seriously interfered with the lifting and dispatching of nursery material and, on the rest of the farm, operations were greatly delayed and in some instances not completed. The months of February, March and April were very mild and consequently the blossoming season was, with one exception, 1938, the earliest since our records began.

All except the earliest and latest varieties of plums, pears, cherries and apples were in bloom during the first fortnight of April, so that by the time the cold spell struck us, as it so often does at the end of April and the beginning of May, most of them had passed the petal fall stage. This year, however, the conditions during the cold spell were different from our usual experience ; for instead of the calm, clear nights and damaging frosts that have been all too frequently of late characteristic of this period, the cold weather was accompanied by strong north-west winds and a heavy snowfall. Although ground frosts did some damage to strawberries, there was little evidence of frost injury in any other fruit crop and, as will be seen, the cropping of most of them was the heaviest on record.

The first six months of the year were again dry, though the rainfall was nearer to normal than in 1944, but some farm crops suffered severely from drought and this may also have affected the set of cherries and Cox's Orange apples.

The early season, as in 1943, was continued throughout the summer. Strawberry picking started on 29th May, raspberries on the 18th June, and by mid-July we were harvesting Rivers' Early plums and Beauty of Bath apples. Despite the heavy crops, the apple harvest was completed by 9th October.

While, in a sense, the heavy crops of 1945 were the culmination of the years that had gone before, it should be realized that, on an experimental farm, such heavy total crops are not necessarily a sign that the farm is fulfilling its proper functions. Several of the older plantations have fulfilled their purposes for research and have only been preserved during the past few years for the sake of the crops they produce in wartime. In coming seasons some of these plantations must be grubbed to make way for new plantings designed to meet the needs of research in the next 20 years. This process has now begun. While it is unlikely therefore that the peak crops of the past year will be equalled, at least for some years to come, the reduction in the acreage of mature trees will release labour to meet the heavy demands for careful work on the younger plantations under experiment.

Experimental Orchards.—Top Fruits.

Apples.—The total crop of 21,700 bushels (40 lb. to a bushel) from 49 acres for all varieties exceeds by 6,500 bushels the record set up in 1939. In addition, in 1945, some 1,150 bushels of drops were marketed as " bag " apples. It may be recalled that, in the years following 1936, our plantations, particularly those of Bramley's Seedling, were gradually thinned, the number of trees being finally reduced by half.

In 1945, for the first time, the remaining trees made full use of the additional space and the crop of 5,900 bushels of Bramley's Seedling exceeded that obtained in 1936 from double the number

of trees occupying the same space—about 9 acres including headlands—the two seasons being comparable in that each followed a year in which frost destroyed the entire crop. The 26-year-old trees of Bramley in the rootstock trials, now at 30 ft. square, averaged some 15 bushels to a tree, while the 32-year-old trees on Kiln Field on mixed rootstocks, now at 24 ft. square, yielded nearly 11 bushels to a tree. The crop of Worcester Pearmain also reached its maximum of 4,100 bushels, the 26-year-old trees in the rootstock trial again averaging well over 4 bushels to a tree. The number of trees of Lane's Prince Albert has been somewhat reduced by frameworking to other varieties in recent years, nevertheless 2,250 bushels, the second highest crop, were obtained. Cox's Orange Pippin were once again rather disappointing, a very heavy drop of immature fruits in early July spoiling what promised to be a good set. The total of 1,890 bushels was still the highest recorded, though in only one plantation was the yield per tree more than 2 bushels. Nearly all other apple varieties yielded heavily and some of them, such as Miller's Seedling, and Early Victoria, needed drastic fruit thinning in order to maintain fruit size. Barnack Beauty, planted at 15 ft. square, with over 6 bushels to a tree, again had the distinction of carrying the heaviest acreage crop of about a thousand bushels, though in this variety the wastage was rather considerable.

Some 500 bushels of various dessert apples and 450 bushels of Lane's Prince Albert were placed in cold store. Most of these were marketed at Christmas. One thousand bushels of Bramley's Seedling were also kept in cold store to the end of February, while 3,700 bushels were gas stored; marketing of these started in the second week of March and was completed by 1st April. All stored fruit kept well and there was little wastage. The increase in the controlled price after 25th February well covered the cost of storage.

Pears.—The 7 acres of pears, most of which are planted at either 12 ft. or 15 ft. square, yielded 3,450 bushels (48 lb. to a bushel) or nearly 500 bushels to the acre, much the heaviest crop to date. Of this about 1 acre of Conference, now mostly about 24 or 25 years old, gave 650 bushels—about $2\frac{1}{2}$ bushels per tree. This brings the average annual crop of Conference pear during the past seven years to 490 bushels to the acre—no mean record, especially as quite a number of trees showing delayed incompatibility and some replants are included. Of other varieties Pitmaston Duchess, Beurré d'Amanlis, Beurré Hardy and Reine des Poires all cropped at the rate of over 3 bushels to a tree. The half-standard Dr. Jules Guyot on layered pear seedlings, at about 18 years old, were rather disappointing, only averaging a little over a bushel to a tree.

Plums.—The total crop of 8,500 half-sieves (28 lb. to a half-sieve) from about $9\frac{1}{2}$ acres in cropping was not the largest on record. This, however, was due to the grubbing two years ago of 3 acres of Giant Prunes to make way for the young interplanted gage collection. All plum varieties carried bumper crops, that of Victoria being outstanding. The total of 4,280 halves of Victoria, nearly double the previous highest crop, was largely due to the heavy crop, over 6 halves to a tree, of the young plantation on Deadman Field, but despite Silver Leaf and breakage, the older trees were also aden. In this season we could have wished for rather lighter yields, for labour was not available for fruit thinning or to give the much needed support to the branches and widespread breakage was sustained. This was of rather less consequence on the older plantations, which had been on the list for grubbing for several years, but in the younger plantations it is likely to have repercussions in the occurrence of Silver Leaf. Every effort was made to reduce this by cutting out broken branches and painting over wounds. Of other varieties, 25-year-old Cherry Plums gave 15 halves, 23-year-old Belle de Louvain and Warwickshire Drooper, $9\frac{3}{4}$ halves and 11 halves per tree respectively.

Cherries.—The crops of all cherries, sweet and acid, were disappointing, 730 halves (24 lb. to a half-sieve) of sweet cherries, from some 12 acres of all ages up to 19 years old, did not approach the crop of 1942, a heavy drop of fruit during the stoning period taking place. During the first week in April, when early and mid-season varieties were in bloom, windy conditions evidently interfered with pollination. The acid cherry crop was also poor and the later blossoming Morellos probably suffered during the cold spell, but lack of young bearing wood was probably also a contributory cause. Most of these trees now need severe dehorning, if they are to be retained.

Small Fruits.

The only considerable area now in small fruits is the 4-acre plantation of black currants on Merryweather. This produced a first small crop in 1945, the second year from planting. The strawberry crop was somewhat reduced by the ground frosts at the end of April and in early May. The small-scale trials of new raspberry varieties cropped well, where they were not reduced by Cane Blight. The growth of new loganberry cane was apparently reduced by the drought in 1944, while training could not always be carried out at the best time; some damage to young lateral growths by snow was also recorded; the crop was therefore considerably lighter than in the previous season, though the quality was good.

Fresh Plantings, Grubbings, etc.

In the autumn of the year a start was made with the post-war planting and grubbing programme. Some 20 acres, including roads and headlands, of dessert apples were planted on the Bradbourne land, 10 acres on Church Fields and 10 acres on Park Farm to the north of Bradbourne House. The latter will be known as Larkfield Plantation. These areas, which include trials of new rootstocks, have been established to meet research needs during coming years. The principal varieties are Cox's Orange Pippin, Worcester Pearmain, Laxton's Superb, Ellison's Orange, Jonathan, Laxton's Fortune and Sunset. Both plantations were fenced in and wired during the winter.

The older plum rootstock trials having fulfilled their purpose, 2½ acres of 23-year-old plums on Egham Field were grubbed while, since the 6 acres of 18-year-old sweet cherries on Church Fields, planted at 30 ft. square, now require all the space, the interplanted plums here also were removed. On Park Farm, the old 5-acre cherry orchard, the trees in which were long past their prime, was cleared during the winter 1945-6. About an acre of seedling raspberries –from which the new varieties now being distributed were originally selected—has also been cleared.

T.N.H., A.P.P.

Experimental Nurseries.

The present time seems opportune to review the development of our experimental nurseries during the years since 1939. The table below gives some idea of the immense increase in this side of the Station's activities.

ACREAGE UNDER NURSERY CROPS, 1939-45.

Year.	Stool beds.	Nursery trees.	Small Fruits, Plum Cuttings, Bedded Stocks, etc.	Strawberries.	Total.
1939 ..	11	6	4½	1	22½
1940 ..	8	6	½	14	28½
1941 ..	11	1	3	8	23
1942 ..	13	1	3	10	27
1943 ..	17	2½	8½	8	36
1944 ..	17	4	13	4	38
1945 ..	17	3	12	2½	34½

At the beginning of the war, part of the original stool-bed area was cleared for food crops. This policy, however, was not long continued. For, in 1941, we were asked by the Ministry of Agriculture to go forward again with the production of clonal rootstocks so as to maintain a nucleus for re-establishing commercial beds. Accordingly 7 acres of the old stool-bed area was maintained and added to by planting another 10 acres at Bradbourne. This area is now in full bearing. How well this request by the Ministry has been met is illustrated by the distribution to the Trade and to our Members of some 3¼ million rootstocks during the last four seasons.

The story with regard to small fruits is very similar. In the four seasons 1940-3 the Station was producing strawberry runners on from 8 to 14 acres each year. As, however, the daughter nurseries under the Ministry's Nuclear Stock Scheme increased production, it has been possible to reduce the area actually on the Station. The area under clonal, disease-free and true to name black currants and loganberries has similarly increased, while in recent years it has been swelled by the large-scale propagation beds of the new raspberry varieties bred at the Station.

While such a policy was fully justified in wartime, it has inevitably made heavy demands on the gradually decreasing manpower on the farm. Further, the lifting and distribution of all this material has become a vast undertaking.

In recent years the Nursery Trade has been encouraged to lay down new stool-bed areas and we have every reason to believe that the response has been good. As these new areas come into cropping, there should be less demand for stocks raised at the Station and our own stool-beds will be reduced to more manageable proportions. In pursuit of this policy some 4 acres of the old stool- and layer-beds, planted in 1928, were grubbed after the crop had been taken off in 1945, and the remainder of the older beds will be grubbed as labour permits.

Similarly, the Ministry's Certification Schemes for Small Fruits should in due course make it unnecessary for us to raise strawberries, raspberries, black currants and loganberries in large numbers, though, as in the case of raspberries at the present time, when the Station has new or particularly desirable rootstocks or varieties to introduce to commerce, we may have to propagate them on a large scale temporarily.

As has already been noted, the weather during the harvesting season 1944-5 had been very unkind. When, however, the weather did change for the better, growth started with a rush, especially the soft fruits. In consequence it was not possible to get the plums and cherries layered as soon as they should have been.

Despite this poor start the crop of rootstocks in 1945 was a record one, some 162,000 up on the previous year.

The total number of stocks produced was 1,308,600 of all grades, of these 701,240 were first grade, 247,360 second grade, suitable only for bedding and 360,000 non-rooted stocks. The last have been planted back at the Research Station for a further year.

The demand for rootstocks was as great as ever. Had treble the quantity been available we should have had no difficulty in disposing of them. Many, whose applications for stocks were received too late, were disappointed.

Some 120,340 raspberry canes, mainly of the new seedling varieties bred at East Malling, were distributed throughout the country. This is an increase of over 80,000 on last year's crop.

The ½ acre of parent loganberry plants produced 7,500 saleable bedded tips.

The 1 acre of Royal Sovereign, Malling 40, produced 100,000 first grade plants. These were lifted and dispatched for the establishment of special nuclear nurseries under ideal conditions.

Verticillium Wilt disease (mainly *V. Dahliae*) developed on an acre of Huxley and Oberschlesien on land previously in arable rotation and, although there is no evidence that this disease is transmitted in the runners, it was decided not to distribute any of these runners pending further knowledge of the disease. The remaining ½ acre of strawberries was made up of small experimental plots.

D.H.H.

Arable Crops.

In 1945 there were some 167 acres under Arable Crops, including 28½ acres of seeds hay and 8 acres of kale and cabbage for cattle feed. During the season 1944-5 a yard of 24 head of store steers was maintained and produced some 400 tons of manure. These cattle were liberally fed on home-grown foods and grew and sold well, thereby considerably reducing the cost of making the dung.

Potatoes.—Twenty-six acres of Majestic and 4 acres of Arran Consul were grown but, in common with other arable crops, suffered severely as a result of the abnormally low rainfall and only yielded just over 7 tons per acre.

Peas.—Nine acres of peas were grown for canning and yielded almost exactly 1 ton of shelled peas per acre, besides which a small but useful stack of ensilage was made from the returned vine. This crop was grown as a preparation for planting maiden apples in the autumn and, besides enriching the soil, provided an excellent opportunity for clearing the ground.

Cereals.—Forty-five acres of wheat yielded 4 qrs. per acre. Thirty-nine acres of Plumage Archer barley averaged rather over 3 qr. per acre and 11½ acres of S.172 oats gave just over 5½ qr. per acre. The effect of the dry growing season was particularly marked in the barley, a large proportion of which was grown on a rather poor, shallow piece of ground and suffered badly from drought in consequence.

Thirty-eight acres of barley and oats were undersown with seeds in the spring, and these seeds grew so luxuriously as a result of early autumn rains, that it was possible to make approximately half the area into ensilage in a rough pit improvised for the purpose.

F.H.V.

Hops.

The acreage remains unchanged at 9¾ acres—8¾ acres of New Varieties and Fuggle in Egham and Church Fields and 1 acre of Goldings at Bradbourne. No extensive grubbing and replanting was done, but eight new selections from Wye were planted out in place of a similar number grubbed.

Owing to the wet autumn in 1944 and the severe winter, the work in the hop garden, as elsewhere on the farm, was seriously delayed. The need to renew a large portion of the wirework in Egham garden accentuated the difficulties, and as a result winter ploughing had to be omitted in Egham garden.

Downy Mildew was at no time serious, but aphis was troublesome in the Bradbourne garden and Mould in the Egham and Church Fields gardens. Possibly owing to the cool, dull and damp weather in August, the Mould made rapid headway, which repeated dustings with flowers of sulphur failed to control. There were great differences in susceptibility amongst the seedling varieties in Egham garden, many being quite free from disease, whilst adjacent varieties were severely attacked. In spite of the adverse season we harvested a crop only slightly less than in 1944, though much was of low quality.

The raising of sets for distribution to growers and for the use of the Pathology Section in disease investigations continues to be a considerable item in the work. Nearly 6,000 sets of eight New

Varieties were distributed to growers. The demand for sets still greatly exceeds the supply and we were unable to fulfill large orders from Canada.

A similar number of sets was raised for use in disease investigations.

F.H.B.

Routine Spraying Programme.

The programme given in the 1942 spray calendar was again followed with slight modifications as necessary. Very unfavourable weather in the late autumn delayed the start of the winter programme till 2nd February. Better conditions, however, prevailed in the spring, and those plots which it had been decided to spray had all been treated by 14th March.

All plums and most of the apples on the Station received a single D.N.C. petroleum wash between those two dates. Some damage to the fruit buds on certain varieties of apples was noted, which was thought to be attributable to over spraying. Control of Capsid and Red Spider was, however, good.

Those apples, which for experimental reasons were not sprayed with D.N.C., received 5 per cent. tar oil followed by petroleum oil emulsion as in previous years.

All sweet cherries were sprayed in the autumn and pre-blossom with Bordeaux mixture against Bacterial Canker, as well as once with 5 per cent. tar oil during the dormant period. It was decided, however, not to winter wash any pears, as the clean condition of the trees as a result of past years' work rendered this unnecessary.

All apples received the usual green cluster scab spray of lime-sulphur, the strength of which was reduced from 2½ to 1 per cent. for sulphur-shy varieties. Two pounds of lead arsenate per 100 gallons was added to the 2½ per cent. lime-sulphur and ½ lb. nicotine to the 1 per cent. lime-sulphur, as there were indications that caterpillar attacks would be bad. A second spray of lead arsenate only was applied in June to secure adequate control of Codling.

In spite of the fact that the pre-blossom period was very short, most plots received a second early application of lime-sulphur at a strength of 1½ per cent.; only one post-blossom scab spray was, however, used. Indications were that there was little scab about and the dry spell after blossoming, unfavourable to scab development, made it seem likely that this would prove adequate. As a result of more humid conditions later in the season, however, a late attack occurred with the result that some fruit was disfigured by small scab spots. Nicotine at the rate of 8 oz. per 100 gallons was added to this one post-blossom scab spray and good control of Sawfly obtained.

Black currants, raspberries and loganberries were treated as recommended in the spray calendar with good results. In the case of hops, however, Mould was found difficult to control, as indicated in the Hop Section.

F.H.V.

Section II

GENERAL REVIEW OF RESEARCH WORK

WITH LISTS OF PAPERS PUBLISHED DURING THE YEAR

I. POMOLOGY

By R. G. HATTON and W. S. ROGERS

A.—Tree Fruits.—Rootstocks.

The long-term rootstock trials of apples, pears and plums bore a good crop and provided further material for estimation of rootstock effect on fully mature trees. After 23 years, the plum rootstock trial had fulfilled its main object, and as many trees—especially of Victoria—were affected with Silver Leaf or badly broken, the trees were grubbed and final weights of trunk and branches obtained. The younger trial of Victoria and Czar on some of the newer selected rootstocks, particularly those likely to give semi-dwarf trees, is still in progress. The trial of Early Rivers, Bigarreau Schrecken and Turkey Heart cherries on clonal rootstocks at 30 ft square required all that space at 18 years old, and the interplanted plum trees were removed.

The trials of Cox and Worcester on various rootstocks on five different soil types in Kent have continued to give useful information on the effect of soil type on rootstock differences.

New Rootstock Trials.

Two small-scale preliminary field trials have been maintained, of Lane's Prince Albert on twenty-four new rootstocks tested for immunity to Woolly Aphid and grown as bushes, and Cox's Orange Pippin worked upon nineteen new rootstocks (the progeny of M. IX crossed with other rootstocks of the Malling series) which are being grown as dwarf pyramids. Annual fruit-bud counts and wood-growth measurements have shown that some of these new rootstocks have a high proportion of fruit buds in the early years, yet maintain vigorous growth.

The full-scale new rootstock trials of bush trees of Jonathan, Cox's Orange Pippin and Ellison's Orange on twenty of the immune rootstocks referred to above, with suitable controls, were planted out at the end of 1945 in similar plots on two soil types at Bradbourne. The trees on stocks expected to give a dwarfing effect were planted at 15 ft. by 15 ft. and 15 ft. by 18 ft., and those on the more vigorous rootstocks at 18 ft. by 18 ft. and 18 ft. by 20 ft.

The trials of double-worked and " bridged-union " Williams' Bon Chrètien pear trees, planted at East Malling and elsewhere, have been maintained. Most of the trees are growing well, including up to the present the single-worked trees on Quince A planted as controls. The trees of Williams' Bon Chrètien on Quince C continue to exhibit " blistered " bark and a few more trees of this combination have died.

Two peach varieties have been budded on dwarfing and vigorous rootstocks and are being prepared for trials as fan-trained trees in the walled gardens.

The two new trials of sweet cherries on acid cherry rootstocks, grown as bushes, made excellent growth.

More than a thousand clonal cherry rootstocks of eight kinds were lined out and budded to provide trees for trials of sweet cherries in bush form.

A further 12 acres of trees, including Cox's Orange Pippin, Ellison's Orange, Laxton's Fortune, Laxton's Superb and Sunset on M. II, M. IV, and M. IX have also been planted for future cultural trials.

(*For rootstocks for cordon trees, see below.*)

Rootstocks in Germany.

At the end of 1945, a special visit was made, at the request of the Control Commission for Germany and the Ministry of Agriculture, to study nurseries and plantations in the British and American Zones of Germany. Interesting observations were made, particularly on the use of the rootstocks M. IX, M. IV, and M. XI, and the effect of severe winter frosts on nursery stool-beds. Two reports have been issued.

Inarching.

Two 23-year-old trees of the variety Grenadier, originally on Malling Crab H and Northern Spy rootstocks, inarched with M. XVI in 1934, were excavated in detail. The amounts and positions of the roots of each component of the multiple root system were studied, in relation to the effect on the tree. Chemical analyses of leaves from different parts of these trees were made.

Cordons and Intensive Culture.

The cordon and dwarf pyramid trials of apples and pears on different rootstocks have continued to give useful results. A paper has been published describing trials of Cox's Orange Pippin and Worcester Pearmain grown as cordons, on six rootstocks, with two pruning methods and two spacing distances (E.219).

The apple and pear cordons in the amateur demonstration gardens bore their first crop in 1945, at two years from planting.

Histological Investigations.

The relation of percentage bark to vegetative vigour has been further investigated, both in apple rootstocks and other plants, particularly *prunus*. Observations have been made indicating a possible connection between anatomical structure and tendency to root from stems in a large range of different woody plants. Nursery trials made with cuttings of *prunus*, to test this hypothesis, gave useful results. This correlation should therefore be valuable in assessing propagation qualities in possible new rootstocks.

Part of the above investigations has been carried out in collaboration with the A.R.C. Unit of Biochemistry, Cambridge University.

A simple test, which is suitable for use in the orchard or nursery, for recognition of the trouble known as "rubbery wood" has been developed and described (E.224). A further short paper describing the abnormal lignification found in this trouble has been published (E.194).

Propagation.

The experimental stool-beds of rootstocks of apple, pear, quince, plum and cherry, planted in spring of 1944, became well established and carried an excellent first crop of rooted layers in 1945. The collection of rootstocks found in commercial circulation was maintained both in layer-beds and in the form of bedded material, and is already proving useful in demonstrating methods of identification.

The Williams' Bon Chrètien pears, worked two years ago direct on a range of quinces for compatibility tests, have not yet shown any marked contrasts in growth. Tests designed to measure strength at the unions of the various combinations will now be made.

Investigations into the propagation of fruit tree rootstocks by cuttings were continued in collaboration with the Physiology Section (see also IIIA). These experiments are concerned with source of cutting material, handling of cuttings and treatment after planting. The hedges planted at Woking and East Malling have provided cutting material for trial and other trials have been planted with material from variously cultivated mother plants. The treatment of Crab C apple rootstock cuttings with a growth substance prior to planting has increased the number of cuttings grown in the year following planting. Further experiments in warming cuttings for periods before planting gave variable and somewhat disappointing results. A further large-scale spacing trial, combined with an irrigation treatment, was carried out.

The Crab C rootstocks budded with various scion varieties and rootstocks in 1944 will remain in position for one more year to provide root cuttings of known history.

A thousand selected and vegetatively propagated pear rootstocks were budded with commercial varieties to provide a source of root cuttings.

Double-working.

A preliminary nursery double-working trial with sweet cherries, designed to produce trees of weaker growth suited to bush culture, was started.

(*See also under New Rootstock Trials above.*)

Cover Cropping.

A paper describing the effect of five cover crops, ryegrass, red clover, ryegrass and clover mixed, lucerne and natural weeds, grown as 2 year leys, compared with clean cultivation under dwarf bush apples, has been published (E.218). The work included quantitative data on the roots and stems of the cover crops, and on tree growth, cropping and leaf scorches. Satisfactory results were recorded.

Two further reports, on the effect of annual cover crops upon apple trees, and on methods of avoiding damage to annual cover crops by winter washes, are in the press. In the trial of grass swards under Worcester Pearmain trees the modified treatments, started in 1943, have caused very definite improvements in tree condition as well as fruit quality, and valuable information has been given on best manurial and management programme for such swards.

Several other trials under apple and cherry trees, in which swards are compared with clean cultivation, have also yielded valuable data on leaf size and fruit quality.

The preliminary trial of various annual, biennial and longer term cover crops under dwarf apple trees has been continued. This includes some less common cover crops such as sweet clover and sainfoin.

Inorganic Fertilizers

The long-term trials of inorganic fertilizers, and the trial of the residual effect of potash in the presence and absence of continued dressings of nitrogen, in clean cultivated plantations, have been continued. Only slight signs of marginal leaf scorch appeared, but interveinal scorch was worse than in 1944. Where nitrogen was applied the interveinal scorch was reduced.

Soil Moisture and Irrigation.

Records of soil moisture changes in plantations under various cover crops and in clean cultivation have been continued. Interesting new data on the favourable effect of older swards on water penetration is appearing. A trial of irrigation on cuttings was continued, as reported above.

Pruning.

A small trial has been started comparing the " renewal " pruning system with the " established-spur " system on mature trees of Cox's Orange Pippin. Some spray damage by a D.N.C. wash in February provided an interesting contrast. Many buds of the long unpruned shoots of the " renewal " system were killed, leaving lengths of bare wood where normally fruit buds should have developed. The fruit buds on the spur-pruned trees were also damaged to some extent, but in this case they sent out lateral shoots. Further observations are clearly needed on these points, but it would appear that it is especially desirable to take precautions to avoid damage by D.N.C. or other petroleum sprays, where the " renewal " system of pruning is used.

The " renewal " pruning system has been continued on the plots of apple trees on five Kent soil types, and has also been used on certain plots showing excessive vigour at East Malling.

New pruning trials of apple and pear dwarf pyramids have been planted in the Bradbourne gardens.

Fruit Thinning.

A thinning trial was carried out on 14-year-old trees of Duchess Favourite on M. IX. This variety has in the past yielded small poor quality fruits. Trees were thinned by the leaf count method, 10, 20, or 30 leaves being allowed to each fruit, the trees being sub-divided for a comparison between early and late thinning. Significant differences have been found between some of the treatments and it is planned to continue the experiment.

Frost Damage Investigations.

Observations on air temperature in grass and clean cultivated plots have been continued. The varying crops of fruit from the plots on five Kent soil types have shed further light on the peculiar nature of the 1945 spring frosts. (*See also under Breeding.*)

Biennial Bearing.

Work on this subject is being intensified. Provision was made for future studies in biennial bearing, by the complete deblossoming of certain Miller's Seedling trees, that were normally in their " on " year in 1945. This has had the effect of putting them in an " on " year condition in 1946, when comparable trees will be in their " off " year. Further material has been provided by the inclusion of Laxton's Superb in the new plantations described above.

Varieties and Classification.

The cordon variety collections for research purposes have been maintained.

Six varieties of peaches have been worked on a single rootstock for a trial of bush peaches in the open in the small Bradbourne garden.

The collection of apricot varieties, planted as fan-trained trees, bore a few fruits, while the collection of acid cherry varieties of the Morello type on the north and east walls bore good crops.

The plums, acid cherries and quinces beside the stream in the arboretum of rootstock varieties, established for purposes of reference and growing naturally as trees, bore their first crops in 1945.

Breeding.

About two thousand apple seedlings have been kept under close observation, and most of these fruited in 1945, many for the first time. Their fruit characters, including their suitability for culture as new varieties, have been carefully studied and the more desirable seedlings selected. The search for earlier ripening varieties of similar appearance to Worcester Pearmain has resulted in the selection of several seedlings thought to be suitable for this purpose. In particular one seedling from the cross, McIntosh Red × Worcester, after extensive trial at East Malling and other localities, is being sent out to over 400 growers under the name, *Tydeman's Early Worcester*. Samples of its fruit sent to Covent Garden Market this season have been favourably commented upon. (See p. 121 and frontispiece.)

In order to help in the evaluation of the fruits of later maturing seedlings, raised to provide late keeping apples of good quality, an underground air raid shelter has been converted into a well-equipped natural fruit store.

A large number of apples with Northern Spy as one parent, and known to be very highly resistant to Woolly Aphid attack, are now coming into bearing on M. IX. Many of the fruits have proved good and several varieties of commercial promise have been selected.

Observations on flowering season of new seedlings in relation to frost injury have been maintained with a view to the selection of late flowering apples of commercial promise. Material is in preparation for the resumption of breeding work deliberately designed to produce late flowering apples of good quality. As opportunity has offered, studies on the inheritance of many important characters have been continued. A comprehensive survey, undertaken in collaboration with the Biochemistry Section, has shown differences among the seedlings in their reaction to mineral deficiencies.

Several hundred pear seedlings from crosses between the best commercial varieties gave their first real crop in 1945. Several have shown promise and are being given a further trial.

B.—Small Fruits.—Classification, Nomenclature and Varieties.

Raspberries.—The crop of 1945 was heavy where it was not reduced by cane blight. For the fourth year in succession, Seedling " L " cropped more heavily than any of the other eight varieties; on the four-year average its crop was about 35 per cent. heavier than that of the next heaviest. The second, in 1945, was Norfolk Giant ; Seedling " H ", which was second in 1944, was third ; and the fourth was Seedling " F ". These four have so far proved more resistant to cane blight than the remainder. The most susceptible was Seedling " E ", which had in consequence the lightest crop, lighter even than Baumforth B.

In fruit size, Seedling " E ", which has previously been the largest, was this year down to fifth place, clearly on account of the severe damage by cane blight. The largest was Seedling " L ", which thus came first in both crop and fruit size. Experiments on the control of cane midge, particularly in relation to its association with cane blight, have been started (See V and VIB).

The first of the new seedlings to be named is now being sent out as *Malling Promise*. Since it was selected from a later batch of seedlings, it has not yet had as extensive trials as those previously distributed. It is, however, known to be outstandingly resistant to virus infection and appears satisfactory in growth and cropping. As its fruit is very large—considerably larger than any of the other seedlings—it seems likely to be particularly suitable for marketing in chips and punnets. (See p. 133).

Loganberries and other hybrid berries.—A new collection has been established to replace the old variety collection, which has been grubbed.

Strawberries.—The strain and variety trials have been continued, and have provided further evidence that degree of freedom from virus diseases is the most important factor, within a variety, affecting cropping. The virus-free Royal Sovereign M. 40 and the Huxley M. 43 and M. 44 of relatively low virus content, maintained their superiority in vigour and cropping. In the trials of virus-tolerant varieties, it was not possible to apply effective aphis-control measures in 1944, and some spread of virus breakdown has been evident. Under these conditions it has been interesting to note that the Huxley clones M. 43 and M. 44 have shown much less breakdown than the best selected commercial stocks planted beside them.

An identification key for the most commonly grown commercial varieties of strawberry based on leaf characters with a view to use for runner-beds has been published (Esf. 51).

Propagation.

Strawberries.—The Strawberry Nuclear Stocks Scheme was brought to a successful conclusion, having served its purpose of showing that virus-tested stocks can be successfully propagated on a large scale in isolated nurseries. Over six million plants were raised and distributed to the industry during the three years of the Scheme. Experience in the maintenance of virus-tested stocks, gained in this Scheme, has formed the basis of the Ministry of Agriculture's new Special Stocks Certificate Scheme which was launched in 1945.

Raspberries.—The special cane nurseries at the Research Station gave a good crop of plants.

Breeding.

Raspberries.—Several new batches of seedlings from crossed and selfed seeds were planted out in June and later. Those planted early grew more vigorously than any previous batches; some already show much variation in cane and leaf characters.

Black Currants.—The cropping trials of promising new seedlings have been continued. Three new varieties have been sent to the National Fruit Trials, and another selection, having exceptionally late fruits, will be sent during the winter, 1945-6.

Strawberries.—Several families of seedlings raised from crosses between Royal Sovereign, Sir J. Paxton, Pillnitz and Huxley are being planted out for trial. Of nine families planted out in replicated trials, three have shown some promise in their first full cropping year. Virus-tested clones of these are being raised.

Cultural Measures.

Loganberries.—Manurial and cover-cropping treatments have been begun on a new trial of clonal loganberries. Records have been continued on loganberry plants propagated from "tips" and from leaf-bud cuttings.

Black Currants.—The trial of different organic manures before planting, including straw, has continued to give interesting results. A repetition of the original manures is now planned. Two further trials have been started, one including sewage sludge, meat and bone meal, inorganic nitrogen, nitrogen plus phosphate, and control plots, and the other straw-sludge, compost, town refuse compost, inorganic nitrogen in autumn and in spring, and at both periods.

The trial comparing close-planted bushes cut down in alternate years with wider-spaced bushes normally pruned has been continued.

Irrigation.

In spite of the relatively light crop, a significant improvement from irrigation was shown in the strawberry irrigation trial.

Frost Damage Prevention.

The trial of strawing methods in relation to frost damage gave interesting and encouraging results, but it will be be desirable to continue the treatments for a further period before reporting upon them.

C.—Nuts.

The older walnut trees on the Research Station bore a fair crop in 1945. These include eighteen varieties from the collection of prize-winning sorts, selected from the many varieties shown at an R.H.S. Walnut Exhibition in 1929, and a collection of nuts of so-called Mayette and Franquette types from grafted trees obtained from the Continent. Useful data have been obtained with regard to the relative value of many different varieties, which have shown the importance of using tested clonal material; revised estimates of certain varieties are included in this report. (See p. 70).

D.—Horticultural Meteorology.

The routine records were maintained. Studies of temperature as affected by cover crops and by strawing of strawberries were continued. Soil moisture studies under various cultural conditions were continued, as reported above.

A curious cracking of young apples, possibly connected with meteorological conditions, was noted in Worcester Pearmain and other varieties and is described on p. 75.

Publications during the Year.

In Relation to Tree Fruits.

A Note on the Use of Synthetic Growth Substances on Plum Rootstock Layer Beds. R. J. Garner and E. S. J. Hatcher. Rep. E. Malling Res. Sta. for 1944 (1945), 34-6. (Eg31.)

A Guide to the Use of Fruit Tree Rootstocks. R. J. Garner. Rep. E. Malling Res. Sta. for 1944 (1945), 98-104. (Eg32.)

Outdoor Tomato Trials, 1944. H. M. Hughes. Rep. E. Malling Res. Sta. for 1944 (1945), 38-43. (E221.)

Planning a Cherry Orchard. N. H. Grubb. Rep. E. Malling Res. Sta. for 1944 (1945), 104-6. (E222.)

Accelerating Rootstock Research. A. Beryl Beakbane and E. C. Thompson. Monthly Science News, No. 6, 1945, and Rep. E. Malling Res. Sta. for 1944 (1945), 106-8. (E223.)

Recognition of the " Rubbery " Condition in Lord Lambourne and Some Other Apple Varieties. A. Beryl Beakbane and E. C. Thompson. Rep. E. Malling Res. Sta. for 1944 (1945), 108-9. (E224.)

The Bradbourne Walled Gardens. T. N. Hoblyn. Rep. E. Malling Res. Sta. for 1944 (1945), 115-7. (E225.)

A Survey of Planting Problems. R. G. Hatton. Rep. E. Malling Res. Sta for 1944 (1945), 96-8. (E226.)

Cover Crops for Fruit Plantations. 1. Short-term Leys. W. S. Rogers and Th. Raptopoulos. J. Pomol., 1945, **21**, 120-39. (E218.)

1. The effects of five cover crops grown for two years and then turned in, are compared with those of clean cultivation in an apple plantation. The crops were (i) Perennial + Italian Ryegrass (*Lolium perenne* and *L. italicum*) ; (ii) Broad Red + Late Red Clovers (*Trifolium pratense*) ; (iii) Ryegrass and clover mixed ; (iv) Lucerne (alfalfa, *Medicago sativa*) ; and (v) Natural weeds (mainly *Poa*). The tree varieties were Cox's Orange Pippin, Beauty of Bath, Worcester Pearmain and Duchess' Favourite, all on No. IX rootstock, and twelve years old when the crops were sown.

2. Large amounts of green material were produced in two years, varying from 14 tons per acre for lucerne, clover, and ryegrass + clover, to 1·75 tons for weeds. The clovers had a markedly stimulating effect on the growth of the grasses mixed with them.

3. Studies on the root system and of the top : root ratio of the cover crops showed that with an established cover crop the top : root ratio in April was from 0·6 : 1·0 to 1·8 : 1·0 Thus, besides the weight of top, a very considerable amount of organic matter was added to the soil by the roots, practically equal to the weight of top at the time of turning in.

4. During their growth the cover crops caused a check on tree growth, but when they were turned in they had a stimulating effect. Both the check and the stimulation varied with different cover crops, being greatest with the ryegrasses in each case. The cover-cropped trees had not quite caught up with the clean cultivated ones in two years following the turning-in of the cover crops.

The check was probably due to competition both for nutrients and water. Manures were deliberately witheld, except for 168 lb. of sulphate of ammonia per acre over the period of growth of the cover crops, a similar quantity when the crop was turned in, and 224 lb. the following year. The importance of adequate manuring both for cover crops and trees is evident.

5. The total weight of fruit for all four varieties over the four years of the experiment was slightly, but not significantly, larger on the trees on all the cover crop plots than on the clean cultivated ones.

There were indications of a reduction in size of fruit during the growth of the most vigorous cover crops, and increases of fruit yield followed the turning-in of the cover crops in most cases ; but few differences reached significance. Some differences in varietal response appeared.

While the cover crops were growing they greatly improved fruit colour, but there was no such effect after they had been turned in.

6. The cover crops markedly reduced interveinal leaf scorch of the apple leaves. The ryegrass and ryegrass + clover crops had the greatest effect, reducing it in one year to about 10 per cent., as compared with 90 per cent. for trees on the clean cultivated plots. Symptoms of nitrogen deficiency were marked in the leaves of the trees on grass alone, but were much less evident in those on grass + clover. The legume crops had less effect on interveinal scorch while they were growing, but a more beneficial one after turning-in. The possible role of the K : Mg ratio in this effect is discussed.

7. It is concluded that the conditions under which similar short-term cover crops would be most suitable are : trees of good vigour, soil not less than 2½ ft. deep and rainfall not less than 26 in.

per annum. The possibilities of alternative cover crops, such as annuals, including autumn weeds, and long-term swards for different conditions, are noted.

The Intensive Culture of Hardy Fruit Trees. I. Trial of Cox's Orange Pippin and Worcester Pearmain Apple Cordons. A. Beryl Beakbane. J. Pomol., 1945, **21**, 41-52. (E219.)

A description is given of three trials of Cox's Orange Pippin and Worcester Pearmain apples grown as single oblique cordons.

In Trial I the treatments were (1) rootstock (Malling I, II, IV, VII, IX and XII), (2) distance apart of planting in the rows (1 ft. 9 in. and 3 ft. 6 in.), and (3) pruning, (i) pruned entirely in summer in mid-July and mid-September, method S, and (ii) pruned lightly in early August and more severely in late December, method W.

In Trial II four leader tipping treatments were carried out on trees on M. I rootstock.

In Trial III the effect of two planting methods was compared: (i) trees planted at an angle of 45 degrees, and (ii) trees planted upright and lowered to 45 degrees the following August.

Trial I. The results up to the time when the trees were 10 years old were as follows:

(i) *Variety.*—The Cox trees were longer than the Worcesters and had a greater weight of prunings, but there was no difference in stem cross-sectional area, or in weight of scion at lifting. The spurs were much farther apart on the Worcester than on the Cox trees.

When all the treatments were considered together the Cox trees had more fruit buds and more fruit than the Worcesters, but when the pruning treatments were statistically examined separately it was shown that Worcesters with pruning S bore more fruit for their size than any of the Cox trees.

(ii) *Rootstock.*—Trees on M. IX were the smallest in stem cross-sectional area, those on M. VII were next in order of vigour, then came those on M. I and II, which did not differ from each other, followed by those on M. IV and finally those on M. XII. Similar differences in vigour were shown in length of tree and weight of prunings. The weight of prunings from trees on M. IX was only about a quarter of that from trees on M. XII. The weight of scion from the lifted series showed that trees on M. IX were lightest and those on M. XII heaviest. There was no difference in weight between the trees on other rootstocks.

Trees on M. IX and II bore most fruit buds and fruit in the early years, but at the end of the period those on M. I, IV and VII equalled those on M. IX and M. II in fruit buds, though not in crop. Trees on M. IX retained their lead to the end of the period in number of fruit buds, in relation to tree size, i.e. number of fruit buds per unit stem cross-sectional area.

(iii) *Planting distance.*—The closely spaced trees were much smaller than the widely spaced trees. The widely spaced series bore more fruit buds and a heavier crop per tree, but the crop per acre was highest with close spacing.

(iv) *Pruning.*—Trees pruned by method S were slightly smaller and the spurs on them were a little closer together than on trees pruned by method W. Series S trees bore more fruit buds and more fruit than series W with Worcester, but not with Cox.

Trial II.—The spurs were closer together on the leader pruned Worcester trees than on those of which the leader was left uncut. The crop in the first six years after planting was greatest on the trees of which the leader was not pruned.

Trial III.—Two series of Cox and Worcester cordons (i) planted at an angle of 45 degrees and (ii) planted upright and lowered to an angle of 45 degrees the following August, did not differ in the length or girth of the main stem three years after planting.

Abnormal Lignification in the Wood of Some Apple Trees. A. Beryl Beakbane and E. C. Thompson. Nature, 1945, **156**, 145; and Rep. E. Malling Res. Sta. for 1944 (1945), 36-7. (E194.)

(*See also* IV. K. 52; V. C. 210.)

In Relation to Small Fruits.

Key for the Identification of the Commonly Cultivated Commercial Varieties of Strawberries. J. Floor and W. S. Rogers. J. Pomol., 1945, **21**, 34-40. (Esf51.)

An identification key, based on leaf characters and designed especially for use with plants in runner beds, is given for the strawberry varieties Royal Sovereign, Huxley, Sir Joseph Paxton, Tardive de Leopold, Oberschlesien, Mme. Lefebvre, Western Queen, The Duke, Early Cambridge and Perle de Prague. The characters employed are defined and a Table is supplied which gives details of other distinguishing characters of these varieties.

The Planting and Maintenance of Raspberry Cane Nurseries. N. H. Grubb and R. V. Harris. Rep. E. Malling Res. Sta. for 1944 (1945), 109-13. (Esf52.)

Strawberry Runner Supplies and Certificates. W. S. ROGERS. Rep. E. Malling Res. Sta. for 1944 (1945), 113-5. (Esf54.)

Horticultural Meteorology.

Weather Conditions during 1944. H. M. TYDEMAN and A. P. PRESTON. Rep. E. Malling Res. Sta. for 1944 (1945), 43. (H46.)

Miscellaneous.

The Experimental Farm. Section I. Edited by T. N. HOBLYN, with contributions from C. BATES, F. H. BEARD, E. BIDWELL, D. H. HAMMOND and H. M. HUGHES. Rep. E. Malling Res. Sta. for 1944 (1945), 13-16. (E231.)

General Review of Research Work, with Lists of Papers published during the Year. Section II. Rep. E. Malling Res. Sta. for 1944 (1945), 17-33. (E232).

Jesse Amos—An Appreciation. R. G. HATTON. Rep. E. Malling Res. Sta. for 1944 (1945), 11-12.

II. STATISTICS AND RECORDS

By T. N. HOBLYN

During the war years all original field records were stored in the cellars at Bradbourne, only summaries and duplicates being retained in the main Records Office. All the files have now been returned to the Records Office and this has greatly simplified the work of filing and checking. Nevertheless, the Office is now over-full and if the files are to be stored in an orderly and readily accessible manner, additional accommodation is essential at an early date.

Sampling and Variation Studies.

In recent years much attention has been paid to sampling methods, designed to lighten the burden of recording tree growth and cropping and the incidence of pests and diseases. Shortage of recording labour is still acute and the general increase in the number and scope of research projects makes a return to the elaborate and detailed methods of recording of pre-war years unlikely. However, it is hoped that, as conditions become more normal, some elaboration of the methods now perforce being used may be possible. Thus a rather more accurate method of recording the total crop of an apple tree in full bearing than the minimum observations of recent years has now been evolved. During 1945, the sampling methods devised to measure total crop and fruit size have been fully described in a single paper (E220). Recently, attention has been concentrated on the assessment of red colouring in apples. Tests have been made of the ability of observers to measure by eye the colour of fruit in bulk, both on the trees and in the boxes after picking, but such methods have not proved very promising. Detailed observations of the individual apples in a 10 to 15 per cent. sample of the crop have, however, provided a highly satisfactory estimate of the average colour of the whole. The saving in labour over a complete record was of the order of 70 per cent. The method will be tried further before being recommended for general use.

A second year's experience in the Essex red spider investigations has helped to perfect the technique for recording the incidence of this pest. (See also VI. A.)

Variations due to the personal factor in the application of sprays have their influence both on farm practice and experimental design. The results of this study (see V.) have been summarized in a report now in the press ; further observations were made in 1945.

The experiment, reported last year, designed to investigate the variation in Preservative Value (P.V.) in small samples of hops was repeated in 1945. (See also VIII. A.)

A trial was made of the method of reducing experimental error by correcting each plot of trees according to the performance of its neighbours. Under the conditions at this Station, however, local soil differences are not so important as they may be in some trials with annual crops, and the use of the method does not appear to be justified. Much better results have been obtained by making use of records of the previous history of individual trees.

Recording Technique.

For many years it has been realized that no one measurement can adequately reflect every aspect of vigour in fruit trees. Nevertheless it has been impossible, even by sampling, to make all the measurements that might be desirable and it has become the custom to take at least one annual measure on every tree under experiment on the farm, the girth of the trunk, other records being only made where essential. In recent years this one measurement has had increasingly to be relied on and it has therefore been necessary to examine its uses and limitations more carefully. The conclusion of various experiments and grubbing of the trees during past seasons have given excellent opportunities to obtain records of tree weight, and a study is being made of the relationship between trunk measurements and tree weight. Alternative measurements where, through accident or other circumstances, the girth of the trunk cannot be obtained, are also under consideration.

Experimental Design.

The preparation of a memorandum on the design of experiments in Cocoa, now in the press, has afforded an opportunity to summarize present-day ideas on field experiments with tree fruits in general. Field trials are shown to fall into three broad groups, varietal, nutritional and cultural, though particular experiments may embrace treatments that belong properly to more than one group at the same time. In varietal investigations, a plea is put forward for the reduction of the number of varieties by every means in the investigator's power before full-scale field experiments

are embarked upon. Most of the preliminary work in the study of plant nutrition should now be accomplished without the aid of elaborate field experiments, making full use of modern advances in methods for the diagnosis and cure of mineral deficiencies. Field experiments, when required, should be designed so that new treatments can be added as the trees grow older and the investigation advances. Designs for cultural trials are shown to be elaborations of those for nutritional trials, but highly specialized techniques are often called for to ensure that the methods of fruit culture under trial are faithfully imitated in the experimental plantation.

Publications during the Year.

Sampling Methods for the Measurement of Fruit Crops. S. C. Pearce. J. roy. statist. Soc., 1944, **107**, 117-26. (E220.)

It is shown that it is possible to estimate the weight of an apple or plum crop with very fair accuracy by counting the number of boxes or chip-baskets into which it is picked. A discussion is included on methods of computing, and the least number of sample containers that need to be actually weighed.

Methods are given for estimating the mean size of fruit in crops of apples, pears and plums for the examination of treatment differences. For apples, it is recommended that a sample of three-quarters of a bushel be divided equally between the tops of complete stacks of three bushels, for pears, that a similar sample be divided between all full bushel boxes, and for plums, that a sample of 60 fruits be divided between three containers chosen at random.

Lognormal Distributions. S. C. Pearce. Nature, 1945, **156**, 747. (E227.)

A suggestion is made how best to apply the logarithmic transformation to small whole numbers. The proposed variable, $\log(2x + 1)$, is tested using the numbers of apples on different trees of a series.

(*See also* I. E225 and IV. K51.)

III. PLANT PHYSIOLOGY

By M. C. VYVYAN

A.—Vegetative Propagation. (See also I. A.)

Cuttings.

Before the introduction, about 1935, of synthetic growth substances, most attention was given to the study of environmental conditions influencing rooting ; while, since that time, there has been a tendency to study the effects of these compounds in a somewhat isolated manner. Present experiments, therefore, are attempting a comprehensive approach to the problems of propagation from cuttings, with the aim of analysing the various factors, and their interactions with growth substance treatments. For these experiments two varieties have been selected, Myrobolan B plum, which roots moderately well, and Crab C apple, a shy rooter.

It is now known that the physiological condition of the parent plant is of major importance, the best rooting response being associated with cuttings taken from plants grown as a hedge, or alternatively under conditions of semi-starvation. Of three trials planned to elucidate the nutritional effect two have already been started, the first to compare the effects of different degrees of pot-binding—a mechanical restriction—the second a stock-on-stock trial to evaluate the influence of rootstock for differential nutrition effect. The third trial proposed will be one in which parent plants are grown at different levels of nutrition in sand culture.

The wide range of rooting power of cuttings from different stocks has been the focus of extensive studies, particularly from the anatomical viewpoint. From the physiological viewpoint, the production of hormonal substances may in some way be related to rooting power and this aspect will be examined during the course of a general survey of natural hormones in the fruit tree. (See Section D.)

B.—Shedding of Fruits, Blossoms and Leaves.

(a) Preharvest drop of fruits.

Further experiments on the control of this drop were carried out in 1945. Sprays containing alpha-naphthaleneacetic acid at a concentration of ten parts per million (0·001 per cent.) proved very successful in two trials with Beauty of Bath. The dropping of fruits was reduced from 91 to 23 per cent. in one trial, and from 69 to 9 per cent. in the other, with an estimated gain of 290 bushels of picked fruit per acre in each case. A similar spray gave almost as good control with Worcester Pearmain, where the drop was reduced from 59 to 23 per cent., with an estimated gain of 250 bushels per acre. Both this spray and one containing 2-4-dichloro-phenoxyacetic acid gave inconclusive results in a trial with Cox's Orange Pippin, as very few sound fruits dropped from either sprayed or unsprayed trees during the experimental period. In trials with Bramley's Seedling, little control was obtained with a spray and none with dust containing alpha-naphthaleneacetic acid. Plans have been made for trials on other varieties and with other substances.

An article embodying the results of all the experiments so far carried out on these lines at East Malling and a Technical Communication reviewing all the literature on the subject are in the press.

(b) June drop.

No work on this drop was done in 1945, but some trials have been planned for 1946. As naphthalene derivatives have proved relatively ineffective in the past, it is proposed to try indole derivatives and other substances.

(c) Spray-induced drop.

Work on this will be resumed next season.

C.—The Abscission Process.

Many matters concerned with the abscission processes responsible for the shedding of fruits, blossoms and leaves are at present imperfectly known, but there is evidence that the character of the process varies considerably with the age and type of organ and with the variety. It has been reported, for example, that the abscission process responsible for June drop in apples is preceded by active cell-division in the abscission zone, but that the process responsible for pre-harvest drop consists

solely in the gelatinization of the middle lamellae of the cell-walls between adjacent mature cells ; and it has been suggested that this difference in character may be the reason why treatments that control the pre-harvest drop fail to control the June drop. It has also been reported that in certain varieties of apple, which react adversely to sprays, this gelatinization starts at the pith and works outwards, but in other varieties, which react better, the process starts at the periphery and works inwards. The conditions controlling the process are likely to vary with its character and further knowledge may lead to improved methods for the prevention of leaf and fruit drop.

An investigation of the abscission processes involved in the shedding of blossoms, fruit and leaves has therefore been started. Material for this was collected from Bramley's Seedling trees in 1945 and is being used for the development of the necessary technique.

D.—Hormone Relations.

A general survey of the hormone relations of the fruit tree is being undertaken and preliminary work has already commenced. At the present time, little is known of the naturally occurring plant hormones, except for the auxin group, for which the Avena coleoptile method of assay is employed. In the first instance techniques of extraction will have to be developed for woody tissues. Once these are satisfactorily standardized the course of auxin production during the year will be followed in different regions of the tree, and comparisons will be made between different varieties to ascertain if there is any relationship, direct or indirect, with habits of growth, stock effects, etc. As mentioned above, one aspect of this hormone survey will concern the propagative power of different rootstocks ; another will concern the nature of hormone translocation. For the latter enquiry transport experiments with synthetic growth substances are being planned. Synthetic growth substances may also provide a link between auxins and other natural hormones, for a great number of synthetic compounds, with a whole range of chemical structure, are now being produced, with physiological activities differing greatly from those of auxin.

PUBLICATIONS DURING THE YEAR.

Sprays to Prevent Pre-Harvest Drop of Fruit. M. C. VYVYAN. Rep. E. Malling Res. Sta. for 1944 (1945), 118-19. (F41.)

(*See also* I. Eg31.)

IV. BIOCHEMISTRY

By W. A. ROACH

THE investigation of mineral deficiencies in agricultural and horticultural crops under a special grant from the Agricultural Research Council has been continued for a fourth year.

The results of analyses of leaf samples sent by advisory officers and Members suggests that trace element deficiencies are widespread in fruit trees and plants and that a systematic survey is desirable in co-operation with the advisory officers.

Many instances of multiple mineral deficiencies have been obtained in fruit trees. The general conclusions (reported below) drawn from the work on annual crops are therefore of great value for orientating work on fruit trees, from which yield results are obtained more slowly and with greater difficulty.

In agricultural crops responses were obtained in 1944 to diagnostic injections of compounds of iron, boron, copper, zinc and nickel, in addition to manganese. These were followed up in 1945 by field experiments on a factorial pattern on wheat, potatoes, and broad beans to test the significance of these diagnoses. The spraying of these crops with solutions containing these elements was followed by an economically important increase in yield for each crop and for each of the six elements. All these results were statistically significant except the one for copper on wheat, for which the odds were only 14 : 1 that the effect was not due to chance. A non-factorial experiment on cabbages gave corresponding results, but at a low level of significance.

The main general conclusions to be drawn from the results of the spraying experiments are that the more severe the deficiency the more necessary it is to spray early in the life of the plant ; that it is necessary to spray more than once to make good manganese deficiency ; and that the concentration of the spray must be decreased as the season advances. An increase in yield from spraying with a particular element, e.g. copper or iron, appears to be conditional on the presence of the right amount of another element (e.g. manganese). The most striking example was furnished by a field of potatoes that was selected because of the severe and striking symptoms of manganese deficiency. On spraying with manganese sulphate a definite improvement in leaf colour was apparent, but no increase in yield was detected. Spraying with zinc sulphate alone, however, raised the yield from 194 to 220 cwt. per acre—an increase of 27 cwt. per acre (odds 30 : 1)—while the effect of spraying with both zinc and manganese was to raise the yield from 149 to 227 per acre—an increase of 78 cwt. per acre, with odds of over 1,000 : 1 that the effect was not due to chance.

On numerous occasions improvement in foliage colour has resulted from the injection of nickel solutions into fruit trees, both in England and in South Africa. This, in conjunction with the increases in yield as a result of spraying the agricultural crops mentioned above, indicates the possible economic importance of nickel to fruit trees. It may even prove to be essential for the growth of plants.

The results suggest that other elements, such as chromium, titanium, vanadium, etc., which are always present in plants, are also worth testing in a similar manner. (Cobalt, of proved importance to animals, has so far brought about no improvement in any of the numerous injections made into plants.)

Publications are in the press describing progress in the development of the analytical methods necessary for mineral nutrition work. The minuteness of the amount of some of these elements necessitates special refinements of even such sensitive methods as the spectrochemical and polarographic. These difficulties will be enhanced when only minimal amounts of plant material are available, e.g. single fruit and vegetative buds.

During the past year the Section has supplied Dr. B. D. Bolas of the Research Institute of Plant Physiology, Imperial College of Science and Technology, with potato leaves injected on one side with manganese sulphate and not on the other. These he has used for investigating the physiological effects of manganese. The results obtained were so encouraging that he proposes to develop this method for the study of the physiological effects of manganese and other trace elements (see p. 89).

PUBLICATIONS DURING THE YEAR.

Mineral Deficiencies in Agricultural and Horticultural Crops. W. A. ROACH. Rep. E. Malling Res. Sta. for 1944 (1945), 43-60. (K47.)

Progress in the Diagnosis and Cure of Mineral Deficiencies in Cherries. S. G. THOMPSON and W. O. ROBERTS. Rep. E. Malling Res. Sta. for 1944 (1945), 60-3. (K48.)

Combined Mineral Deficiencies in Fruit Trees. W. O. ROBERTS. Rep. E. Malling Res. Sta. for 1944 (1945), 64. (K49.)

Leaf Painting as a Method of Diagnosis of Mineral Deficiency. W. O. ROBERTS. Rep. E. Malling Res. Sta. for 1944 (1945) 67, 68. (K. 50.)

Comparison of Diagnosis of Manganese Deficiency in Mangolds with Effects of Curative Spraying. W. A. ROACH and T. N. HOBLYN. Rep. E. Malling Res. Sta. for 1944 (1945), 67-70. (K51.)

Comparative Susceptibilities of Certain Horticultural and Agricultural Plants to Trace Element Deficiencies. R. J. GARNER and W. A. ROACH. Rep. E. Malling Res. Sta. for 1944 (1945), 70-3. (K52.)

The Cure of Deficiencies of Iron or Manganese. S. G. THOMPSON. Rep. E. Malling Res. Sta. for 1944 (1945), 119-23. (K53.)

Further Work on Plant Injection for Diagnostic and Curative Purposes. W. A. ROACH and W. O. ROBERTS. J. Pomol., 1945, **21**, 108-19; and Imp. Bur. of Hort. and Plant. Crops, Tech. Comm. No. 16. (K46.)

Improvements in the appliances hitherto developed by one of the authors and his collaborators and used for plant injection with liquid for both diagnostic and therapeutic purposes and with solid materials for therapeutic purposes are described in detail and fully illustrated. They include the reduction in weight of the small containers employed for interveinal and leaf-stalk injection by the substitution of cellophane for glass. Special tools for making the cellophane cups are described and illustrated and the sources from which the requisite materials can be obtained are mentioned.

Brief notes are given on the experience gained both in this country and South Africa in the use of injection methods with twenty-five different kinds of plants, including fruit trees and bushes, some forage plants, hops, potatoes, tomatoes, tobacco and a few others. Paged references are given to information contained in previous papers on the subject.

In connection with injection for curative purposes, an improved method for the injection of solids into a tree is described and figured. It consists in drilling a small hole through the bark, continuing it at a slightly decreased diameter into the wood, introducing with the help of a metal tube and plunger the necessary chemicals in tablet form into the wood and sealing them there with a cork disc, over which the bark readily heals. By this method a minimum of mechanical damage is done to the tree.

Studies in the Diagnosis of Mineral Deficiency. II. A Comparison of the Mineral Content of Scorched and Healthy Leaves from the Same Apple Tree. D. W. GOODALL. J. Pomol., 1945, **21**, 90-102. (K44.)

On three occasions during 1942, samples of scorched and apparently healthy leaves, otherwise fully comparable, were collected from the same twenty-four apple trees. On one further occasion in 1943, samples were taken from twelve of the same trees. The laminae were analysed spectrographically for calcium, iron, magnesium, manganese, and potassium; for the samples collected in 1943, the petioles with midribs were also analysed separately, and data for sodium content were also obtained.

In eleven out of the twelve pairs of trees sampled, the scorch symptoms could be related to a low concentration of either magnesium or potassium in the foliage. A comparison of 21-year-old trees of Egremont Russet with trees of the same variety recently topworked on to Bascombe's Mystery showed that the foliage of the former contained more magnesium but much less potassium than that of the latter; this suggests that the trunk can supply much more potassium than magnesium to the young leaves relatively to their requirements of the two elements.

The concentrations of mineral elements in slightly scorched leaves did not differ significantly from that in healthy leaves, with the exception of magnesium which was consistently lower in scorched leaves of trees deficient in magnesium. In severely scorched leaves, the maganese content was also lower than that found in healthy leaves on the same tree.

The only significant seasonal changes in mineral concentration were in calcium, the concentration of which in the leaf increased between July and October, and in magnesium, the concentration of which decreased in trees suffering from magnesium deficiency, but increased in others.

Observations on different morphological types of leaf in general confirmed the author's earlier results.

The concentration of calcium, iron, magnesium and particularly sodium was higher in the petiole and midrib than in the lamina; that of manganese was lower. A high content of iron or manganese in the petiole, due to uncontrolled factors, was associated with a low content in the lamina, and vice versa.

In relation to the question of deficiency diagnosis by plant analysis, the following are the conclusions reached :

Severely scorched leaves should be avoided ; but slight scorch is no disadvantage, and may even facilitate the diagnosis of magnesium deficiency.

Sampling for the diagnosis of magnesium deficiency is best carried out fairly late in the season.

The advantage of spur-leaf over shoot-leaf samples for the diagnosis of potassium deficiency is confirmed.

There is some indication that lamina samples are preferable to petioles for diagnosis of potassium deficiency.

Studies in the Diagnosis of Mineral Deficiency. III. The Mineral Composition of Different Types of Leaf on Apple Trees in Early Summer. D. W. GOODALL. J. Pomol., 1945, **21**, 103-107. (K45.)

Leaf samples collected just before blossoming time in 1941 from Cox's Orange Pippin trees growing in plots receiving different dressings of sulphate of potash and sulphate of ammonia were analysed spectrographically for calcium, iron, magnesium, manganese, and potassium. Two different rootstocks were involved. The basal, middle, and apical leaves of flowering spurs and the basal leaves of non-flowering shoots were gathered and analysed separately.

On the vigorous rootstock (M. XII) the leaves contained less calcium, more magnesium and perhaps more potassium than on the dwarfing rootstock (M. IX).

The iron and potassium content of leaves from flowering spurs was greater than that of leaves from non-flowering shoots. The difference in potassium content was marked only in the trees on rootstock XII. In the flowering spurs, the iron content was greatest in the apical leaves for trees receiving sulphate of ammonia, but in the basal leaves for trees receiving none.

Differences in composition among leaf types and between soil treatments were less marked than in samples collected from the same source in the preceding autumn. This is ascribed to the smaller mass of the early summer foliage relatively to the reserves of nutrient elements in the woody parts of the tree.

The data provide no evidence for choosing one type of leaf rather than another for diagnostic purposes ; but they show once again the importance of basing comparisons between trees only on leaves of the same morphological type.

V. PLANT PATHOLOGY

By R. V. HARRIS

Bacterial Canker of Plum and Cherry.

Spraying trials were continued, with particular reference to Plum, but the natural incidence o cankers on the experimental plantations was again slight as in 1944.

Apple Scab.

(1) Continued use was made of the method designed for measuring the severity of this disea on foliage.

(2) Further data were obtained on the effect of spraying apple trees in full blossom with fungicide

(3) Preparations of an organic mercurial as fungicides were further examined on a field scal in collaboration with the Plant Protective Chemistry Section. (See VII. B.)

(4) A further large-scale experiment was made, in collaboration with the Statistics Sectio (see II), on the influence of the personal factor in routine spraying as regards tree-to-tree variabilit in control.

(5) Further observations were made on the influence of differing manurial treatments on th incidence of the disease.

Apple Canker.

Spraying trials were continued, and preliminary work on the incidence of the disease in relatio to differing manurial treatments was started.

Brown Rot Diseases.

Apple.—An experiment was begun to see whether this disease could be controlled by direc spray treatment.

Nut.—Experimental work to investigate the control of " Nut Drop " by spraying was starte in a grower's plantation.

Raspberry and Loganberry Cane Spot.

Raspberry.—See " Raspberry Diseases Investigation in Scotland " below.

Loganberry.—The weaker copper sprays tested gave satisfactory though incomplete control unt August. At the end of September their beneficial effect was still evident, though much reduce The sprays appeared to be safe.

Raspberry Cane Blight (See also Entomology. VI. B.)

A severe attack of this disease associated with heavy infestations by Raspberry Cane Midg (*Thomasiniana theobaldi* Barnes) on a cropping trial of new seedling varieties at the Research Statio necessitated an intensification of work on control measures against it.

Direct inoculations of raspberry cane with and without wounding to compare the action of th fungus *Leptosphaeria coniothyrium* with that of other fungi also commonly associated with Ca Blight lesions, indicated that certain of the latter fungi are also contributory causes of the disea as wound parasites.

A preliminary attempt, in collaboration with Entomology (see VI. B.), to control both the pe and the disease by means of (i) an insecticide alone or (ii) a spray with combined insecticidal an fungicidal properties yielded promising results from the former, indicating a functional connectio between the insect and the infection of canes by the fungous pathogens. Continued and intensifie research on this problem in collaboration with the Entomology Section has been planned for 1946.

Verticillium Wilt of Strawberry. (See also Hop Diseases. VIII. B.)

Severe outbreaks of this disease both on the Research Station Plantations and in the Wisbec strawberry area were studied and experimental work has been continued and extended along th lines indicated in the Report for 1944.

Virus Diseases of Fruit.

Raspberry.—In addition to the analytical and insect-vector work detailed below (see Raspberr Diseases Investigation in Scotland) observations on grafting tests of selected new seedling varieti

set up in 1944 showed that of five raspberry seedlings tested, four were tolerant to " Lloyd George Mosaic " (Mosaic 1 plus Mosaic 2). Of two new seedlings found to be virus free, one was sensitive to Mosaic 2 and the other tolerant. Norfolk Giant was found to be useful as an indicator to supplement results obtained with Baumforth's Seedling B in grafting tests. Tests of other seedlings and of further selections of Lloyd George raspberry are in progress.

Loganberry.—An investigation of Loganberry Dwarf (Reversion) was recommended and grafting experiments to determine the effect of this disease on other cultivated hybrids and species of Rubus were begun.

Strawberry.—A number of samples of seedlings and commercial varieties (including six East Malling seedlings and one of the Auchincruive Phytophthora-resistant varieties) were tested by grafting to *Fragariae vesca*. Infector tests, with a view to classifying the samples as sensitive or tolerant to Yellow-edge were made. Selected stocks, tested in previous years, have been maintained.

The investigation of the causes of deterioration of stocks of Huxley and other " Yellow-edge tolerant " varieties was continued and some of the work prepared for publication.

Work on the separation of viruses from complexes occurring in the strawberry plant was continued and a number of complexes resynthesized by combination of the viruses already isolated. A description of the technique employed and of the preliminary results obtained was prepared for publication.

Black Currant.—Experiments were made to determine the host range of Black Currant Reversion.

Other Fruits.—A survey of commercial plantations has brought to light the existence of a number of virus and suspected virus diseases of pome and stone fruits. Controlled experiments to find whether certain of these diseases are graft-transmissible were begun.

Raspberry Diseases Investigation in Scotland.

In this second year of the Investigation the programme of research has been continued and developed principally along the following lines.

Virus Diseases. (See also Raspberry Virus Diseases above.)

Results of experiments made in 1944 which became available in the present year, in conjunction with the parallel research at East Malling (see below), indicate that the virus situation in raspberries is of greater complexity than had been assumed from earlier work. Five distinct symptom types have been identified, some of which appear to originate from multiple viruses. All the viruses concerned appear to occur in current Scottish stocks of Lloyd George, three of them being " carried " (i.e. without the expression of diagnostic symptoms). This still widely grown variety is therefore the main source of trouble in the " Strathmore " raspberry growing area at the present time.

The important Leaf Curl disease, not yet reported south of the Border, has been specially studied, but progress is very slow owing to its highly lethal nature and the present lack of information on its natural vectors. Evidence, however, was obtained of the extreme sensitivity of this disease to climatic factors, and this may have some bearing on its apparent absence in the south.

Numerous experiments were also started in Scotland and at East Malling to determine the natural vectors of raspberry viruses with special reference to the two common raspberry aphids. The results of these experiments will not be fully available until 1946.

Spraying Trials.

Spraying trials against the important fungus disease Cane Spot were made with the co-operation of Messrs. Chivers & Sons. During this season a devastating attack of Raspberry Moth (Red Bud Borer) also occurred and, in consultation with our Entomology Section and Dr. A. E. Cameron of the Edinburgh and East of Scotland College of Agriculture, these trials were therefore enlarged to explore the joint control of both fungus disease and this important pest. Positive results were obtained indicating a promising field for future joint investigations by research plant pathologists and entomologists. A need for adequate machinery for the routine spraying of raspberries was also very apparent and preliminary steps were taken to remedy this.

Isolated Cane Nursery Scheme.

Of the five plots leased to the Investigation for the propagation of nuclear stocks of healthy cane in isolation, four were planted up in March of this year. Of these, three were planted with the East Malling clone of Norfolk Giant and the fourth with a promising Kentish stock of Lloyd George also originating from our East Malling clone.

Cane growth has been good on all the sites. In particular, the performance of the two highlan plots in West Perthshire is considerably more promising than was expected under such rigorou growing conditions. Of the two plots situated locally, one—in the Carse of Gowrie—in addition t propagating Norfolk Giant, has been used for housing some selections from specially promising Nort Scottish stocks of Lloyd George whilst these are undergoing tests for virus content.

As soon as the results of these tests become available, infected samples are to be discarded an any found to be virus-free will be propagated.

The remaining plot on Loch Tay-side is being reserved specially for propagating tested stock of Lloyd George, and is being prepared for planting this autumn. In addition to promising Scottis sources of Lloyd George, samples have recently been received from New Zealand by the courtesy o the Department of Agriculture of New Zealand. These samples are to be tested next season.

Diseases of Hops. (See VIII. B.)

PUBLICATIONS DURING THE YEAR.

"Mercurated Lead Arsenate": What is it? What does it do? H. SHAW and M. H. MOORE. Rep. E Malling Res. Sta. for 1944 (1945), 128-30. The Fruit-Grower, 1945, **100**, 121-2 and 14 The Grower, 1945, **24**, 112 and 130-1. (Under change of title.) (C193.)

A Note on Medlar Cluster-Cup Rust (*Gymnosporangium confusum*, Plowr.) **in Kent in 1943 and 194** M. H. MOORE. Trans. Brit. myc. Soc., 1945, **28**, 13-15. (C194.)

A severe aecidial attack in 1943 and a slight attack in 1944 of the uncommon Cluster-Cup Rus *Gymnosporangium confusum*, Plowr. on *Mespilus germanica* in a Kent garden are described. Tw bushes of a variety of the teleutospore host, *Juniperus Sabina*, were growing nearby.

A Black Apple Rot caused by *Monilia cinerea*. H. WORMALD. Gdnrs' Chron., 1945, **117**, 115; an Rep. E. Malling Res. Sta. for 1944 (1945), 75-6. (C205.)

The Control of Bacterial Canker and Leaf Spot in Sweet Cherry. H. B. S. MONTGOMERY and M. H MOORE. J. Pomol., 1945, **21**, 155-63. (C207.)

Bacterial Canker, due to *Pseudomonas mors-prunorum* Wormald, was well controlled over fou seasons on the susceptible Bigarreau de Schrecken cherry by spraying with Bordeaux mixture bot in autumn (at 10 : 15 : 100) and spring (at 6 : 9 : 100 pre-blossom). Each spraying separately con tributed partial control, while spring sprays, especially that at petal-fall, controlled moderate Lea Spot. Foliage damage followed the use of this spray stronger than 4 : 6 : 100 post-blossom, but th addition of edible cottonseed oil (0.75 per cent. by volume) prevented this in the one season in whic it was tried. The incidence of the disease on Schrecken was influenced by rootstock and by seasona conditions, and that of spray damage on Napoleon, Rivers, and Frogmore by rootstock.

Three Important Hop Diseases. W. G. KEYWORTH. Rep. E. Malling Res. Sta. for 1944 (1945) 130-4; J. Min. Agric., 1945, **51**, 556-61. (C209.)

An Experiment on the Control of Crown Gall on Vegetatively raised Apple Rootstocks. H. WORMAL and R. J. GARNER. Rep. E. Malling Res. Sta. for 1944 (1945), 73-4. (C210.)

Strawberry Leaf Blotch Fungus. H. WORMALD. Rep. E. Malling Res. Sta. for 1944 (1945), 76-7 (C211.)

The Control of Brown Rot of Apples in Commercial Orchards. H. WORMALD and M. H. MOORE Rep. E. Malling Res. Sta. for 1944 (1945), 124-6; The Fruit-Grower, 1945, **99**, 450; Th Grower, 1945, **23**, 492 and 496. (Under change of title.) (C212.)

Certain Aspects of Resistance of Plum Trees to Bacterial Canker. Part III. The action of cell-fre filtrates of *Pseudomonas mors-prunorum* Wormald and related phytopathogenic bacteri on plum trees. D. ERIKSON and H. B. S. MONTGOMERY. Ann. appl. Biol., 1945, **32**, 117-2 (C213.)

A technique for introducing 2-3 cc. liquid into the bark of plum trees is described. Paralle injections with dyestuff throughout the spring failed to afford a reliable index of the invasive powe of the various test fluids introduced in this manner.

A susceptible variety of plum (Giant Prune) showed greater injury by cell-free filtrates of *Ps mors-prunorum* than did a resistant variety (Warwickshire Drooper), which showed negligible injury The greatest injuries were caused by filtrates of cultures five weeks old and over, especially whe concentrated.

Of other bacteria tested *Ps. prunicola*, *Ps. syringae* strains, *Syringa* 3, Ap. No. 1, Ap. No. 2 and *Bact. prumi*, yielded damaging filtrates, whereas *Ps. syringae*, strains pear 6 and 7, *Ps. tabaci Ps. fluorescens*, *Ps. marginalis*, *Ps. phaseolicola*, *Ps. tumefaciens*, *Ps. pisi* and *Ps. cerasi* failed to do so

Some evidence is advanced for the view that the deleterious activity of *Ps. mors-prunorum* may be due in part to an endotoxin of protein nature obtainable from the dried bacterial cells by acetic acid extraction.

Physiologic Races of the Crown Gall Organism in Britain. H. WORMALD. Trans. Brit. mycol. Soc., 1945, **28**, 134-46. (C214.)

Previous descriptions and work on crown gall in Britain are reviewed.

Investigations on crown gall at the East Malling Research Station were started in connection with its occurrence on apple rootstocks, but gall-inducing isolates were obtained from a number of other hosts for comparison.

The organisms examined showed differences in their host relations and reactions in culture, and four categories can be distinguished.

Of two of the organisms isolated one was from a common weed (curled dock) and the other from a hedgerow plant (bramble).

Hop Diseases in Great Britain. W. G. KEYWORTH. Wallerstein Lab. Comm., 1945, 8, 99-109. (C215.)

This general account of hop diseases in Great Britain, written for publication in America, indicates the main lines of research during the past six years and collates information already published elsewhere. The diseases are described and illustrated, and brief notes included on control measures.

(*See also* I. Esf. 52.)

VI. ENTOMOLOGY

By A. M. MASSEE

A.—Tree Fruits.

Apple Blossom Weevil.

Further biological observations at East Malling and in Essex, the latter by members of the Field Laboratory, Great Braxted, have confirmed the results obtained in 1943 and 1944. It is now proved that oviposition is closely related to bud development, beginning at the bud burst stage and continuing for three weeks.

In field trials at East Malling a 5 per cent. D.D.T. dust applied at bud burst and again a week later gave excellent control. Dusts of 3 per cent. D.D.T. and 3 per cent. 666 were less effective. Another field trial at Danbury, Essex, showed 3 per cent. D.D.T. to be superior to 3 per cent. 666 the former giving a commercial control when heavy applications were made.

Using sprays containing D.D.T. in suspension a complete kill of test insects was obtained in the laboratory at 0·05 per cent. concentration; slightly lower kills were recorded at 0.025 per cent. (See VII. A.)

Papers dealing with (*a*) the biology and (*b*) the control of this pest are now awaiting publication.

Woolly Aphid Parasite.

Experiments to overwinter this parasite in cold storage—under the same conditions as apples are stored commercially—are being continued for a third season. The parasites kept in cold storage in the winter 1044-5 at a temperature of 30° F. emerged very successfully in the following June. They were introduced into twenty commercial apple plantations in Essex with marked success.

Fruit Tree Red Spider.

Special investigations are being carried out at the Field Laboratory, Great Braxted, Essex, and at East Malling. A further study of the life-history of the Fruit Tree Red Spider is continuing in the field and laboratory. The different stages of the animal have been recognized; the number of generations may vary from season to season; the populations of summer and winter eggs are being estimated; the rate of increase of the mites tends to vary according to the health and vigour of the tree. Many other aspects of the life-cycle are also being studied.

Alternative host plants of the mite are being looked into, and several common orchard weeds are known to harbour all stages of the mite during the summer months.

Migration phase.—The study of this important aspect is being continued, and the technique evolved for the purpose has proved adequate. In 1945, a steady migration within the orchard proceeded throughout the summer months.

Predaceous insects.—This project, which is the subject of a special research grant, is being conducted at the Field Laboratory at Great Braxted, Essex. Of the twenty odd predators feeding on the Fruit Tree Red Spider, a predaceous capsid proves to be the most important, and has been noted under certain conditions to cause a considerable decrease in the spider populations. A study of this capsid and other important predators continues.

Field spraying trials.—Spraying trials are in progress to determine the value of certain winter washes against the eggs of the mite. (See VII. B.) The "mangle" or "leaf imprint" technique for recording the results of the spraying trials has again proved adequate. The method is especially valuable since it gives a permanent record of the results of the field trials.

Laboratory tests of Insecticides on the eggs of the Fruit Tree Red Spider.—The new technique of rearing mites on young apple seedlings has proved invaluable, and should materially simplify the testing of summer and winter eggs under laboratory conditions. (See VII. A.)

The effect of D.D.T. dust on some beneficial insects associated with apple.

Preliminary observations have been made on the effect of a D.D.T. dust upon certain predaceous insects found on apple.

Apple Capsid Bug.

Field spraying trials are in progress in a commercial orchard to determine the correct timing of certain ovicides against this pest. (See VII. B.)

B.—Small Fruits.

Strawberry Blossom Weevil (*Anthonomus rubi*).

Laboratory trials indicate that 5 per cent. dusts of both D.D.T. and 666 give promise of controlling this pest in the field. Large-scale experiments cannot at present be undertaken as no suitable material is available in the neighbourhood.

Strawberry Rhynchites (*R. germanicus*).

One dusting with 3 per cent. D.D.T. gave complete freedom from this pest for a fortnight. Further information is being obtained on the emergence of adults from hibernation and the number of dusts required to prevent injury.

Strawberry Aphids.

Eight species have so far been found breeding on cultivated strawberries; their importance is being studied.

Strawberry Aphid Survey.

Population counts of *Capitophorus fragariae* Theo. have continued from May to August on selected farms in Hampshire, Worcestershire and the Isle of Ely. Similar counts on selected farms in Kent and at the Research Station are made at regular intervals throughout the year. Sufficient information is now available to define within fairly narrow limits the spring migration period. There are also indications that a correlation exists between maximum infestation and fruit development.

An undetermined species of *Aphidius* was found parasitizing *C. fragariae* at Evesham. This is the first recorded parasite.

Strawberry Aphid Control by Nicotine Vapour.

An experimental machine has at last been obtained. Preliminary tests indicate that 95-99 per cent. kill can be obtained, if plants are subjected to nicotine vapour for 45 seconds at a dosage of $3\frac{3}{4}$-4 lb. pure nicotine per acre. All Research Station plots were treated during the summer.

Strawberry Insects.

The fauna of the cultivated and wild strawberry is being studied in conjunction with insects of commercial importance.

Gooseberry and Currant Aphids.

Work on the biology of these has continued as time permitted.

Raspberry Mosaic.

Amphorophora rubi and *Aphis idaei* have been tested as possible vectors of Mosaic 1 and 2, using Lloyd George and Norfolk Giant as sources of infection and healthy canes of the latter variety as indicators. No symptoms have yet developed. (See V.)

Rubus Insects.

A weekly survey during the summer months is being continued on two plots of raspberry, one of which is sprayed at regular intervals. The insect population of the two plots varies considerably, but the spread of virus disease is very slow and is similar on both plots.

Raspberry Cane Midge.

A study of the life-cycle and control measures of this midge has been started under field conditions. The investigations to date show very clearly there is a close correlation between the midge and certain parasitic fungi which attack the stem of the plant.

This investigation is being carried out in collaboration with the Pathology Section. (See also I. Small Fruits, and V.)

Control of Tarsonemid Mite.

A mite population is being built up on a series of experimental plants to enable further tests of insecticides to be made.

Black Currant Leaf Curling Midge.

A plot of black currants is being established to enable the life-cycle and control of this insec to be worked out.

Systematic Study of the Phytoptidae.

Some little attention has been given to this group of Gall mites.

The British Tetranychidae or Red Spiders.

Material sent in by economic entomologists has been examined and determined.

PUBLICATIONS DURING THE YEAR.

Laemostenus terricola L. (Col., *Carabidae*) **Feeding on Stored Apples.** A. M. MASSEE. Ent. mon Mag., 1945, **81**, 9. (D187.)

The adult stage of the Carabid Beetle, *Laemostenus terricola* L. is reported feeding on storec apples under dry storage conditions.

Notes on some interesting insects observed in 1944. A. M. MASSEE. Rep. E. Malling Res. Sta. fo 1944 (1945), 77-83. (D183.)

Observations on the life-cycle of the Apple Blossom Weevil (*Anthonomus pomorum* (L.) Curt.). R. M GREENSLADE. Rep. E. Malling Res. Sta. for 1944 (1945), 83-92. (D184.)

The Hop Red Spider (*Tetranychus telarius* L.). A. M. MASSEE. Rep. E. Malling Res. Sta. for 194 (1945), 126-7. (D185.)

Codling Moth (*Cydia pomonella* L.). A. M. MASSEE. Rep. E. Malling Res. Sta. for 1944 (1945) 127. (C186.)

The County Distribution of the British Hemiptera-Heteroptera. E. C. BEDWELL and A. M. MASSEE Ent. mon. Mag., 1945, **81**, 253-64, and 265-73. (D188.)

The additions to the distribution of the British Hemiptera-Heteroptera since the publication o Butler's great work of 1923, entitled " A Biology of the Hemiptera-Heteroptera ", are given in char form similar to that originally published by Butler.

VII. PLANT PROTECTIVE CHEMISTRY

By H. SHAW

A.—Laboratory Investigations.

Chemical.

Further work on the standardization and analysis of pest control products has been carried out and has included collaborative analyses of tar-petroleum and D.N.C. washes and Paris Green.

In an attempt to throw light on the mechanism of the fungicidal action of thiuram disulphides, the decomposition of these substances *in vitro* has been investigated. The dialkyl and tetraalkyl derivatives behave quite differently on heating. The latter group has been examined more fully and here it has been found that the type of solvent in which the substance is heated determines the course and end products of the decomposition. Preliminary attempts have been made to correlate fungicidal activity with the facility of the liberation of amine and carbon disulphide under standardized conditions. The products of the atmospheric decomposition of thin films of thiuram disulphides and dithiocarbamates have been examined. A series of di-*n*-alkyldithiocarbamates has been synthesized for the purpose of studying the influence of constitution upon toxicity.

Amine salts of dinitrophenols have been prepared and are being tested as insecticides and fungicides, especially against Red Spider.

Certain aspects of the decomposition of D.D.T. are being investigated.

Ovicides.

Against eggs of *Aphis pomi* a number of derivatives of carbazole and phenanthridine were toxic at 0.1 per cent. whereas several pyridine derivatives were not toxic at 0.5 per cent. β-Butoxy-β′-thiocyanodiethyl ether was again the most toxic of several thiocyanates tested. *p*-Chlorophenol was more toxic than the corresponding chloroxylenols as were also the bromoxylenols. Most of the materials used were prepared by the Chemical Research Laboratory of the D.S.I.R.

Contact Insecticides.

A wet spray containing 0.05 per cent. D.D.T. gave a very high kill of Apple Blossom Weevil. (See VI. A.)

A wash containing the di*cyclo*hexylamine salt of 2 : 4-dinitro-6-*cyclo*hexylphenol was tested against Fruit Tree Red Spider on apple seedlings (see VI. A.) and against Hop Red Spider. (See VIII. C.)

Fungicides.

The main groups worked on during the year were the dithiocarbamates and substituted phenols. Several homologous dithiocarbamates were tested and some indications of the relation of structure to toxicity emerged.

Attempts were made, with some success, to find a criterion of germination, e.g. differential staining, alternative to inspection of germ tubes.

B.—Field Investigations.

Insecticide Trials.

Raspberry Beetle.—In 1945 a range of concentrations of D.D.T. in the form of Guesarol E. (dispersed solid) was tested in one trial and several different types of preparation in another. As Guesarol E., D.D.T. at 0·0125 per cent. was as effective as a derris wash containing 0·004 per cent. rotenone and only a little, though significantly, less effective than D.D.T. at higher concentrations. A report on the earlier trials has been published. (Q38.)

Apple Sawfly.—Extreme variability of both crop and infestation made the results obtained of little value. Lethane 384 at 0·05 per cent. β-butoxy-β′-thiocyanodiethyl ether gave no control, and nicotine at 0·05 per cent. and two forms of D.D.T. at 0·05 per cent. were only just significantly better than no treatment.

Codling Moth.—Several different preparations of D.D.T. at 0·05 per cent. were, in general, less effective than lead arsenate at 0·2 per cent. There were indications of differences among the D.D.T. preparations but significance was barely established.

Apple Capsid.—The experiment on the effect of time of application of a D.N.C.-petroleum wash was continued for a second year. (See VI. A.)

Fruit Tree Red Spider.—In the A.R.C.-Pettar-Ace trials in Essex the comparison of D.N.C.-petroleum with straight petroleum miscible oil, each applied in January, February, and March, was continued. Miscible oil and stock emulsion petroleum washes were compared in a March application. (See VI. A.)

Fungicide Trials.

Apple Scab.—In an intensive spraying trial on young Cox's Orange Pippin trees, phenyl mercury chloride in several different types of preparation was tested pre- and post-blossom. It was not more effective than 1 per cent. lime-sulphur except at 0·01 per cent., dispersed in sulphite lye, and this was phytotoxic. At 0·005 per cent. it was safe and, except in the form of a dispersion of china clay, was the fungicidal equal of 1 per cent. lime-sulphur. A demonstration trial on established Cox's showed that the normal lime-sulphur schedule was superior to 0·005 per cent. phenyl mercury chloride in sulphite lye applied at the same time. The mercurial at 0·005 per cent. on lead arsenate was greatly inferior. (See V.)

Publications during the Year.

Field Trials of Dichloro-Diphenyl-Trichloroethane (D.D.T.) against the Raspberry Beetle. H. Shaw. J. Pomol., 1945, **21**, 140-5. (Q38.)

αα-Bis-(*p*-chlorophenyl)-βββ-trichloroethane (D.D.T.) has been compared with Lonchocarpus ground root in field trials against the Raspberry Beetle (*Byturus tomentosus* Fabr.). In each of two proprietary forms, one of which was of an unsatisfactory physical nature, and in a laboratory preparation, D.D.T. at 0·025 per cent. or at 0·05 per cent. gave as good control as a Lonchocarpus spray containing approximately 0·011 per cent. rotenone. The difference between treated and control plots was highly significant, but there was no significant difference in control as between either the products or the concentrations. In 1943 a single spraying with each one of the materials was only moderately effective against a fairly heavy infestation, whereas in 1944 double spraying gave an excellent control of a lighter infestation irrespective of the spray used. In no case was there any evidence of phytotoxicity. The proprietary material more satisfactory on physical grounds left a deposit on the fruit that made the earliest pickings unsaleable. Possible means of overcoming this disadvantage are suggested.

Destroy Fruit Tree Pests by Spring with D.N.C. Wash. H. Shaw. Popr. Gdng., 1945, **46**, 410. (Q39.)

A brief, popular account of the control of certain garden pests by spraying in winter. Special mention is made of the D.N.C. dual purpose wash and precautions necessary to secure good results are outlined.

(*See also* V. C193.)

VIII. HOPS

A.—Varieties and Cultivation Trials.

By F. H. BEARD

Commercial Varieties.

The second season's crop records from the trials of early and late Goldings indicate that there are no great differences in yield. Samples of cones were taken from each clonal selection and records made of size of cone, number of petals and amount of seed. Significant differences were noted. Analyses of the 1944 and 1945 crops showed that the Early Bird clone has a very high P.V. for an English commercial variety. Samples of the seven clones were submitted to the Institute of Brewing for use in brewing tests, but owing to technical difficulties in the laboratory at Birmingham no useful information was obtained. It is hoped to submit samples again in 1946. A propagation trial has shown that there are differences between the clones in number and size of sets produced from strap-cuts.

The trial designed to measure the amount of variation in P.V. which occurs between individual hills of a Fuggle clone has been repeated. (See II.) The data confirm the findings of the previous season. Individual hills have a consistently higher or lower P.V. than the mean. An account of the investigations is in the press.

New Varieties.

The crops from some 88 new varieties raised by Professor Salmon at Wye were picked and dried separately to indicate cropping capacity and provide material for brewing tests. Samples of 34 varieties were collected in air-tight jars for P.V. determinations by Dr. T. K. Walker and his assistants at Manchester. Small pockets of six varieties have been sent to a well-known firm of brewers for brewing trials. Fewer varieties were dried separately and submitted for analysis and brewing trial than usual owing to the incidence of Mould. Varietal differences in susceptibility to Mould are reviewed on p. 107. The above work is being carried out in collaboration with Professor E. S. Salmon.

The systematic testing of all the New Varieties for resistance to Verticillium Wilt continues. (See VIII. B.)

Cultural Trials.

Most of the original cultural trials have been concluded and material for new trials is in preparation.

Propagation Trials.

In view of the need for a rapid increase of stock of the New Varieties, healthy clones of the older varieties, and in particular those varieties resistant to Verticillium Wilt, attention is now being given to methods of intensive propagation and to the improvement of the "take" of cuttings in the nursery. A special research assistant has been appointed by the Agricultural Research Council for this work.

Layering is being used for the rapid multiplication of the four best Wilt-resistant varieties.

The possibilities of large-scale propagation by soft-wood cuttings made from surplus basal shoots and the lower laterals are being explored. This season the trials have been confined to Fuggle and four Wilt-resistant varieties. Propagation by soft-wood cuttings made from suitably selected basal shoots has proved successful, but further research is needed, especially in relation to the use of growth substances, which proved deleterious when applied to Fuggle cuttings in 1945.

In trials designed to show varietal and seasonal variation in the take of strap-cuts in the nursery, distinct varietal differences in both the number and size of sets produced have been found. A report on trials to compare layer and runner cuttings with strap-cuts appears on p. 104 of this Report.

A comparison of three distances of planting strap-cuts in the nursery rows showed that whilst the number and size of sets produced increased with wider spacing, close planting gave the greatest number of sets of planting size from a given area of ground.

B.—Diseases of Hops.

By W. G. KEYWORTH

Verticillium Wilt.

(*a*) *Survey.*—During 1945, ten outbreaks were newly reported to the Research Station from Kent and Sussex. Of these, one was a progressive outbreak of at least three years' standing and

seven others were possibly of the progressive type, two of them being in north-west Kent, an area which has previously been apparently free from this form of the disease. Five previously unknown outbreaks were notified (two in the West Midland area) during the Ministry of Agriculture inspections for the certification of Wilt-free gardens.

(*b*) *Resistance trials* of the Wye Seedling Varieties were continued and four selected for further testing. Field trials on a commercial scale have been started using six varieties selected during 1943-4.

(*c*) *Studies on fluctuating and progressive outbreaks.*—Pathogenicity studies on the strains of *V. albo atrum* from different outbreaks have been continued and the results obtained in previous years by soil inoculation with natural infected plant material followed up by using pure cultures of the fungi involved.

Observations were again made on outbreaks in commercial gardens, in particular those of the fluctuating type. The main objects of these studies have been to record the incidence of wilt from year to year and to determine whether wilt intensity is related to bine vigour as influenced by cultural operations. The investigation on the effect of soil conditions on wilt intensity has been continued.

Virus Diseases.

(*a*) *Nettlehead.*—Tests of selected Wye Seedling Varieties have been continued in order to determine whether any are tolerant to the disease and an experiment has been laid down to study the transmission of Nettlehead in the field.

(*b*) *Mosaic.*—Routine testing of a number of male hops and Wye Seedling Varieties has been continued.

Lightning Damage.

A case of lightning damage to hops was noted at Rainham, Kent, in which the discharge had travelled to earth from the bottom wires through the lower portions of bines touching the wires. Some 20 per cent. of the rows in the garden were affected and all the plants in these rows were damaged to some extent. The injury varied from slight cortical discoloration of the bases of the bines to complete scorching of the basal portions, with subsequent wilt of the bines at times varying from one to six weeks after the date of injury.

Ministry Certification Scheme.

Collaboration was maintained with the Ministry of Agriculture in the working and development of the Ministry Scheme, particularly in the identification of virus diseases and the testing of specimens for Verticillium Wilt.

C.—Insect Pests of Hops.

By A. M. MASSEE

Hop Eelworms.

Experiments are in progress to test the eelworm (*Heterodera rostochiensis* Woll.) as a possible vector of Mosaic and Nettlehead. The investigations made in 1944 gave negative results.

Hop Red Spider.

Tests are being made with certain new insecticides under field conditions and in the laboratory. (See VII. A.)

Publications during the Year.

Cultural Trials with Hops. IV. The effect of distance of planting and hard and light pulling on Brewer's Favourite. F. H. Beard. Rep. E. Malling Res. Sta. for 1944 (1945), 92-5. (B52.)

Hop Growing in Great Britain with Special Reference to Research Work. F. H. Beard. Wallerstein Lab. Comm., 1945, **8**, 83-98. (B53.)

A brief historical survey is given of hop growing in the British Isles. This is followed by brief descriptions of past and present practices together with a review of research work. The subject is dealt with under the headings of soils, varieties, propagation, systems of wirework, distances of planting, dressing, pulling, training, stripping, cultivations, manuring, spraying, picking, drying and marketing.

Twenty-eighth report on the trial of the New Varieties of Hops. E. S. SALMON. August, 1945. (B51.)

Of the 131 New Varieties tested, one cropped at the rate of 26¼ cwt. to the acre and 25 at from 20 cwt. to 24¼ cwt. to the acre—notwithstanding the very dry growing season of 1944.

For the third successive season a number of Anglo-American hybrids were grown with only one bine to the string; heavy yields were obtained, 16 varieties cropping at the rate of 20 cwt. or over to the acre. Trained in this way, "Bullion Hop" (Q43) and "Brewer's Gold" (C9a) gave 23¼ cwt. and 22¾ cwt. respectively.

The average yield per acre of "Brewer's Gold" over 16 years at East Malling Research Station now stands at 25¾ cwt., and of "Bullion Hop" over 10 years at 26 cwt.

The number of bushels (Imperial) of green hops required to the cwt of dried hops varied from 75 to 134.

High analyses are recorded for a number of the New Varieties, one outstanding variety being "Northern Brewer". Two varieties grown at Tenbury, Worcestershire, gave a higher analysis than the same varieties grown at East Malling.

OM26, a bud-sport of the "Nonsuch Hop" (OB53), was richer than its parent by 1·53 per cent. α-resin and 0·42 per cent. β-resins. Similar results have been obtained for 10 consecutive seasons.

It is pointed out that the two New Varieties, "Northern Brewer" and "John Ford Hop" (raised from the "Canterbury Golding" crossed with a male hop seedling of "Brewer's Gold") have exceptional keeping properties. It is considered probable that these varieties will in course of time replace the Golding varieties "Cobb's" and "Tutsham".

Attention is drawn to the two New Varieties OR55 and OJ47, both of which have been found by Dr. Keyworth to possess some resistance to Verticillium wilt.

In recent Brewing Trials with certain New Varieties, both OR55 and OJ47 (see above) were given a favourable report.

Particulars are given of the Competition for the Challenge Cup offered by brewers for the best growth in 1944 of a New (Wye) Variety of Hop.

It is pointed out that 52 firms of brewers have undertaken to purchase annually some 6,000 cwt. of certain of the New Varieties. In 1944, 1,003 pockets, or approximately 1,504 cwt., of the New Varieties were distributed by the Hops Marketing Board. It is evident, therefore, that the existing acreage of the New Varieties requires to be considerably increased in order to meet the brewers' requirements. In this connection it is urged that an Experimental Station in the Weald should be established, where the approved New Varieties can be tried out on Fuggle soil.

(*See also* V. C.209, C. 215; VI. D.185.)

IX. TECHNICAL SECTION

External contacts of all kinds have greatly increased during 1945, especially as regards visitors to the Station, which numbered over 1,250, including 32 organized parties, apart from the Annual Members' Day, when some 500 attended. The cessation of hostilities in Europe in the spring made it possible for groups of scientists from the liberated countries to visit the Research Station, and many valuable contacts were made. During the summer months allied servicemen and women made use of leave periods to pay visits, frequently with little or no notice. Inquiries by 'phone and letter have steadily increased. No record of the former exists, but our records of the latter show that 1,449 were of such a nature that they could be dealt with by the Section, apart from 1,243 of a more specialized nature that needed the personal attention of the research worker concerned.

Nineteen technical articles of a popular nature suitable for fruitgrowers and amateurs were published during the year, and further assistance was given in writing and editing the fruit bulletins of the Ministry of Agriculture. Six talks were broadcast in the B.B.C. " Farming To-day " programme; unfortunately they had to be of a very general nature, and could not be addressed specially to fruit-growers.

Assistance has been given to County Officers in various parts of the country by lending slides, photographs, films and complete exhibits, and by arranging for speakers. Close co-operation has been maintained with the Kent Education Committee in running classes in fruitgrowing for school teachers.

Publication during the Year.

Success to your Fruit Growing. H. M. Hughes and H. B. S. Montgomery. Ideal Home and Gdng., 1945, **52,** 149-51. (E201.)

An illustrated account of the main considerations in planning and planting an amateur fruit garden with practical suggestions for a simple 5-rod fruit garden and a more elaborate 10-rod one. In the list of desirable varieties for these gardens, special note is made of those varieties that are reported as successful in many parts of England, Scotland and Wales.

Section III

RESEARCH REPORTS

POMOLOGY

THE INTENSIVE CULTURE OF HARDY FRUIT TREES

II. A TRIAL OF DWARF PYRAMID TREES ON MALLING ROOTSTOCKS

By A. BERYL BEAKBANE and LESLIE R. E. MARTIN

Introduction.

At the beginning of the present century M. Lorette (1914) described chandelles or fuseaux trees which in many respects closely resembled the form now generally referred to in England as dwarf pyramid. The first account of the dwarf pyramid system of apple culture in this country was published by A. H. Lees (1928). A few years later a demonstration of Lees' method was established at the Somerset Farm Institute at Cannington and described in a report of the Institute (1935) and by Bagenal and Turner (1936). These English methods differ considerably from those practised by M. Lorette especially in the treatment of the lateral shoots. A similar type of tree on M. IX rootstock is grown widely in the Rhineland, under the name of Spindelbusch, but the branches are trained more horizontally, being bent down by metal clips or by tying with string to the main stem (Fey and Wirth, 1944). The Spindelbusch trees are planted much farther apart, viz. 9-10 ft. square, and less summer pruning is practised than is usual under most of the English dwarf pyramid systems. Hobbis (1944) has, however, described in detail the behaviour of a successful commercial dwarf pyramid plantation, which, in recent years, has been managed with winter pruning only.

Since further information on the dwarf pyramid system for apples was required as rapidly as possible, a small preliminary trial of Cox's Orange Pippin was planted in 1937, although the ideal trees and land for the purpose were not then available. It was decided to use two contrasting rootstocks of greater vigour than would ideally have been chosen rather than postpone the trial for several years. The land available was also not the most suitable for the purpose, as it was rather variable due to previous excavations. In spite of these difficulties, however, it proved possible to study the technique for managing trees under the dwarf pyramid system and to show differences in behaviour due to rootstock and pruning treatments. The knowledge gained enabled us subsequently to choose a pruning method which has proved successful for a number of varieties planted in 1944 and grown as dwarf pyramids at Bradbourne. These trees, which were on rootstocks selected as the most suitable for intensive cultivation, began to fruit in their second season after planting.

Planning and Planting.

Maiden (1-year-old) trees of Cox's Orange Pippin on M. I and M. XVI were planted at 6 ft. by 3 ft. apart in March, 1937. The trial was planned in three randomized blocks with three trees to a plot. The twelve plots were arranged in two rows and the trial was surrounded by guard trees. The guard rows contained Allington on M. IX in addition to Cox on M. I and M. XVI.

Pruning Treatments

The pruning treatments are referred to as L and S for convenience indicating that the lateral shoots were left fairly long with method L and cut shorter with method S. It may be of interest to note that the treatment of the laterals in trees pruned by method S is similar to that described as method S in an earlier trial of cordon trees (Beakbane, 1945).

Method L.

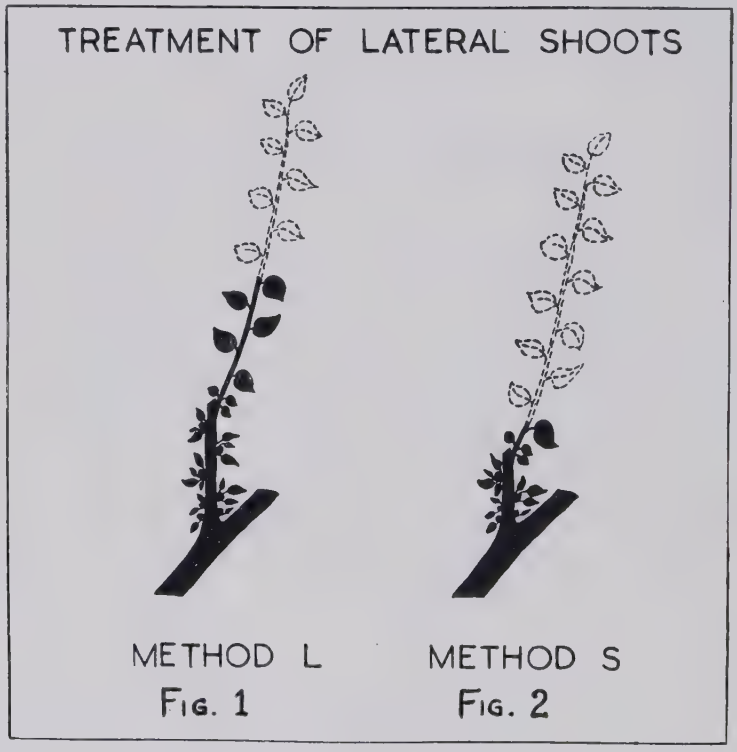
The maiden trees were cut to 20 in. in April, and any lateral shoots (feathers) present on the maiden were pruned to about five buds, choosing an end bud pointing in a downward or outward

direction. The following summer and thereafter any laterals and branch leaders over 12 in. in length were pruned to about five leaves in mid-July (Plate I, Fig. 1). In counting the leaves the cluster of small leaves which often occurs at the extreme base of the shoots was omitted. At the end of the growing season any secondary shoots were cut to their point of origin.

Method S.

The maiden trees were cut to about 20 in. in the dormant season. At this time the lateral shoots were pruned to about half their length.

The following summer and thereafter the lateral shoots were pruned in mid-July to three leaves when arising from a main stem and to one leaf when arising from an existing side-shoot (Plate I, Fig. 2; and Plate II). If secondary growth occurred, the process was repeated in September. This was not found to be necessary except in very wet summers.



Drawing by E. C. Thompson.

PLATE I.

Diagram showing methods of pruning lateral shoots of dwarf pyramid apple trees in summer.

During the dormant season the central and branch leaders were cut to about half their length, the amount removed being adjusted to ensure that the central leader was higher than any of the branch leaders.

General pruning notes applying to both systems.

The leaders were pruned in consecutive years to buds pointing in opposite directions in order to maintain a vertical position. When the trees reached about 7 ft. in height the central leader was cut to about half its length in May instead of in the dormant season, and from then on any shoots arising from the top of the trees were pruned to $\frac{1}{2}$ in. in May to restrict their growth. Branch leaders were cut to $\frac{1}{2}$ in. in May, when the end of the branch reached a position about 18 in. from the central stem in a horizontal plane, i.e. when branches of adjacent trees touched along the row. No thinning out of fruiting laterals was done, but this may be needed in future years.

Rootstock Effect.

At 10 years old the area of cross section of trunk was more than twice as great in trees on M. XVI as in those on M. I (Table I). Although trees on M. IX occurred in the guard rows only and were not included in the trial, it is interesting to note that they were smaller than those on M. I.

TABLE I.

Pruning treatment.	Trunk size 1945. Area of cross section sq. cm. Rootstock. I.	Trunk size 1945. Area of cross section sq. cm. Rootstock. XVI.	Number of Fruit Buds relative to tree size 1945. Rootstock. I.	Number of Fruit Buds relative to tree size 1945. Rootstock. XVI.
L.	9·4	21·7 }	119 }	36 }
S.	11·4	26·4 }	88 }	26 }
Mean ..	10·4	24·1	104	31

Differences that are not significant are indicated by brackets.

Comparisons of fruitfulness are based chiefly on fruit buds, because spring frosts destroyed the crop in three years, while severe infestations of apple blossom weevil reduced the crop in several years and more particularly in 1940. In Table I the number of fruit buds is expressed in relation to tree size. The number of fruit buds relative to tree size was more than three times as great on M. I as on M. XVI. In making this comparison the area of cross section of trunk was taken to represent tree size, since in trees of this kind, which are pruned in summer, a measurement of extension growth is not easily obtained. The relationship between tree and trunk size is known for trees which are similarly treated, but to use this relationship between different pruning treatments and rootstocks is not strictly valid. If the true values were known, however, it is probable that they would accentuate the differences shown by the estimated values.

The actual number of fruit buds per tree is shown in Table II for the years in which records were made. Trees on M. I began to have many more fruit buds than those on M. XVI as early as 1940. Even on the vigorous rootstock M. XVI, however, growth did not become unmanageable and towards the end of the period the trees showed signs of becoming more fruitful, viz. the difference in number of fruit buds between trees on M. I and M. XVI was much less than in the earlier years.

TABLE II.

Rootstock.	Number of Fruit Buds per tree. 1938.	1939.	1940.	1942.	1943.	1945.
I. ..	4	6	29	19	100	124
XVI. ..	2	0	3	0	51	103

Although the trial trees did not crop freely, the guard row trees on M. IX similarly treated bore some good crops. In normal years, from 1942 onwards, trees on M. IX bore from 40 to 50 fruits or approximately 10 lb. per tree, which is equivalent to about 550 bushels per acre. Since these trees were very small, it is probable, however, that a rootstock intermediate in vigour between M. IX and M. I would be preferable for dwarf pyramids. Although the trees on M. XVI were somewhat restricted in size by close planting and summer pruning, the delayed fruit bud production on this rootstock makes it unsuitable for dwarf trees.

Rootstock influence on growth and fruiting was thus clearly visible in these dwarf trees and was comparable to the effect observed by Hatton (1935) with bush trees.

Pruning Effect.

The two pruning treatments affected the general appearance of the trees. On the whole trees pruned by Method S were more upright and stouter in appearance than those pruned by Method L, which induced a more rounded tree shape with a dense head of thinner and finer shoots.

With rootstock M. I, trees pruned by Method S were significantly larger, as indicated by tru size, than those pruned by Method L. The differences in number of fruit buds relative to tree si apparently in favour of Method L on both rootstocks, were not significant (Table I).

Conclusions.

The intensive cultural conditions of the trial appear to have caused little, if any, masking rootstock influence, as is shown by the clear effect on growth and fruit bud production obtained w trees on different rootstocks grown as dwarf pyramids. While the pruning effect was not so cle there was a suggestion that pruning affected tree size and fruitfulness. The method of pruni chosen for a subsequent plot of dwarf pyramid trees, based on the results obtained from this tri has proved successful in bringing the trees into bearing at an early age.

Summary.

A description is given of a trial of Cox's Orange Pippin trees grown as dwarf pyramids. T treatments were (1) *rootstock* (Malling Nos. I and XVI), (2) *pruning*: (i) branch leaders pruned summer, laterals lightly pruned (Method L); (ii) branch leaders pruned in winter, laterals mc severely pruned (Method S).

At ten years old trees on M. XVI were more than twice as large as on M. I. The trees on M. bore more fruit buds in relation to their size than those on M. XVI. There was a suggestion th trees pruned by Method L were smaller and more fruitful than those pruned by Method S.

Acknowledgements.

The writers wish to thank Mr. N. B. Bagenal for helping to initiate the trial, Dr. H. B. Montgomery for advice on the presentation of the results, and several members of the Pomolog Section for recording tree growth and fruiting.

References.

Anon (1935). "An Intensive Method of Apple Production, Dwarf Pyramid System." *Somers Farm Inst. advis. Rep.*, 114-28.

Anon (1932). "Intensive systems of apple production." *Bull. Minist. Agric. Lond.*, **49**.

Bagenal, N. B., and Turner, A. D. (1936). "Dwarf Pyramid apple culture at Cannington." *Sc Hort.*, **4**, 67-74.

Beakbane, A. B. (1945). "The intensive culture of hardy fruit trees. I. Trials of Cox's Orang Pippin and Worcester Pearmain apple cordons." *J. Pomol.*, **21**, 41-62.

Fey, W., and Wirth, A. C. (1944). "Der Spindelbusch, ein Idealbaumform fur den Garten d Selbstversorgersund fur Erwerbsobstpflanzungen." (The spindlebush. A kind of dwa pyramid, an ideal tree shape for home gardens and commercial plantings.) *Grundlagen Fortschritte im Garten-u.*, Weinbau, 1944, Heft 58 (6th revised edition).

Hatton, R. G. (1935). "Apple rootstock studies. Effect of layered stocks upon the vigour an cropping of certain scions." *J. Pomol.*, **13**, 293-350.

Hobbis, E. W. (1944). "Intensive systems of apple production with particular reference to dwa pyramids." *Rep. Long Ashton Res. Sta. for 1944*, 15-21.

Lees, A. H. (1928). "The new intensive system of commercial apple growing." *Gdnrs' Chron* **83**, 340-1, 356-7.

Lorette, L. (1914). "La Taille Lorette." Bibliothèque du Journal "Jardinage." Laboratoire Georges Truffaut, 90 bis Avenue de Paris, Versailles. pp. 235, figs. 82, bibl. Nil.

——— (1925). "The Lorette System of Pruning." Translated by W. R. Dykes. Martin Hopkinso Ltd.

Photograph by E. C. Thompson.

Plate II.

Cox's Orange Pippin dwarf pyramid apple tree.
Ten-year-old tree pruned by Method S.

[*face p.* 48

Fig. 1.

The Product of Unit Plots of Myrobolan B in 1944.

Upper row shows " middle cuttings " and lower row " basal cuttings " from each soil. In 1944 the sand plot was waterlogged.

THE BEHAVIOUR OF HARDWOOD CUTTINGS OF TWO PLUM ROOTSTOCKS ON FOUR SOILS

By R. J. GARNER

Introduction.

The vegetative propagation of selected rootstocks is an important feature of modern fruitgrowing. One of the most attractive methods (Knight and others, 1928) is the autumn planting, in the open ground, of one-year shoot cuttings, though only a few of the rootstocks in common use can be propagated satisfactorily in this way.

The method is almost confined to certain varieties of plum and quince; among the plums, Marianna and the vigour-inducing rootstock Malling Myrobolan B being the two examples commonly encountered.

The technique which yields satisfactory results at East Malling Research Station with Myrobolan B has been described in detail from time to time (Garner, 1943 and 1944) and, because of the simplicity of the method, a stand of 50 per cent. or over is considered satisfactory, though returns at East Malling have often reached 75 per cent. and more. Such returns have not, in general, been attained by commercial rootstock raisers in other localities and these failures merited some enquiry. A review of recent studies in propagation by cuttings (Garner, 1944) has revealed that such investigations can be considered under three heads, A., Source or material; B., Handling prior to planting; and C., Planting and subsequent treatment. Each rootstock raiser normally collects his cuttings from plants grown in his own locality and the effect of environment on this parent material is reflected in the performance of the cuttings after planting. The condition of the parent plants is an important factor (Sinha and Vyvyan, 1943) and it is misleading to compare the behaviour of cuttings collected from material of different ages and culture in order to test for any effect of handling, soil, or subsequent treatment. Clonal material of one grade from one source has now been planted on two very different soils to provide material suitable for cuttings which will be the subject of further trials, the results from which cannot be available for two or three seasons.

In the trials under review, cuttings were taken from one parental source and handled exactly alike; only the site, soil and climate of the planting situation varied. The trials thus come under heading C., subsequent treatment.

Material and Methods.

The two plum rootstocks, Myrobolan B (*Prunus cerasifera*) and Brompton (*P. domestica*) were selected for experiments. The first roots well under normal conditions, the second is somewhat spasmodic in its behaviour.

The Myrobolan B cuttings were collected from a mature hedge and the Brompton from an established layer bed, both at East Malling Research Station. Yearling shoots from the hedge were collected and divided into two equal lengths, the lower 12 in. of the basal half was designated a basal cutting and the lower 12 in. of the apical half the middle cutting. The Brompton shoots were collected from the layer bed by severing the longer one-year shoots some 18 in. above their base. These shoots when collected were divided as described for shoots from the hedge. Thus there were two grades of each variety, making four types of cutting. The cuttings were collected and planted in mid October. Similar trials were conducted in the two seasons 1943-4 and 1944-5. The soils were of four kinds, Malling loam, an old lake bed at East Malling, and two sands at Bagshot. The Malling loam is on the Hythe beds of the Lower Greensand, excellently drained, where fruit trees make good healthy growth and Myrobolan B cuttings normally give stands of over 50 per cent.

The Lake soil is highly calcareous and fine textured, with an admixture of peat and a definite peat layer at a depth of 15 to 18 in. This soil was irrigated by diverting a nearby stream, the water from which percolates through the peat sub-soil and rises to the soil surface. The behaviour of fruit-nursery and agricultural indicator crops on this soil has already been described (Garner and Roach, 1945).

Two types of Bagshot sands were selected; one, considered most typical of the Bagshot district, the other containing particles of peat and, for present purposes, known as " black sand ".

These sands are somewhat coarse-grained, often containing " ironstone " pans, and are almost devoid of either clay or carbonate of lime. Rainfall percolates rapidly except where the pan holds up the water near the surface, in which case peat immediately accumulates, and forms the " black sand ".

In the second trial, planted in 1944, the chosen site on the more typical sand was at a higher level in relation to the surrounding country and contained a fair amount of small pebbles, whilst the black sand was selected at a much lower level which was later found to become waterlogged for considerable periods. The black sand had a definite hard pan at 14 to 18 in. beneath the surface.

Samples collected from each of the soils in 1944 at the end of May, a critical period for cuttings, revealed moisture contents as shown in Table I.

TABLE I.

PERCENTAGE LOSS OF WATER FROM SAMPLES OF SOIL IN 1944 EXPERIMENTS.

Depth.	Malling Loam.	Lake Soil.	Bagshot Sand.	Bagshot Black Sand.
0– 6 in. ..	12	45	13	9
6–12 in. ..	13	57	14	12
12–18 in. ..	13	51	13	15

It will be noted that, except for the very moist lake soil, the soils differed little in moisture retaining properties.

The cuttings were all prepared at East Malling at one time and divided equally for the four sites. Those for Bagshot were carefully packed by a method which retained the adhering leaves in a healthy state. The freshly made cuttings were laid two deep on a length of 3 ft. wide hessian folded to 18 in. so that the apical end of each cutting was level with the folded edge. Cuttings and hessian were sprinkled lightly with water, and the 6 in. of spare hessian was folded over the base of the cuttings and the whole rolled tightly from one end and tied with cord. The packed cuttings arrived in excellent condition and some spare cuttings carried to and from Bagshot before planting at East Malling behaved similarly to unpacked cuttings. In 1943, planting was carried out on October 12th and 13th, in 1944, on October 18th-20th.

The planting was the same on each site ; the cuttings were set 9 to 10 in. deep, spaced 2 in. apart in rows running north to south, 15 in. apart. Guard rows of Myrobolan B were planted at either side of each experimental unit and spare cuttings at the ends of each row. The whole trial in each year consisted of four four-by-four latin squares, two hundred cuttings of each treatment being planted on each of the four sites.

Behaviour of Cuttings.

First Trial, 1943-4.

All the sites were inspected towards the end of January, 1944 and the cuttings found to be alive and apparently healthy. Five cuttings drawn from the guard rows of Myrobolan B on each site had all callused well. Two cuttings from the lake soil had one and two roots respectively, each an inch long. All plots were visited again in March. It was remarked that the soil of both the Bagshot plots was very moist close to the surface in spite of the scarcity of rain at that time.

TABLE II.

CUTTINGS GROWING IN SPRING.

	1944.		1945.	
	Basal.	Middle.	Basal.	Middle.
MYROBOLAN B on—	%	%	%	%
Malling loam	95	76	34	90
Lake soil	92	51	85	82
Bagshot sand	95	68	75	90
Bagshot black sand ..	85	41	96	64
BROMPTON on—				
Malling loam	85	64	77	58
Lake soil	86	79	96	75
Bagshot sand	93	70	93	71
Bagshot black sand ..	93	73	60	32

On May 24th and 25th a note was made of the condition of each cutting, whether it was A. alive, but not extending new growth ; G., extended ; W., wilted, or D., dormant or dead. The percentages of cuttings growing at that time are shown in Table II. These figures indicate that, up to the end of May, the cuttings showed no clear differential effect due to soil, except that the smaller middle cuttings of Myrobolan B were somewhat adversely affected by the black sand. This seems to indicate that the Myrobolan cuttings, which are active much earlier than the Brompton, were already showing the influence of soil. Brompton cuttings, being slower starting into growth, did not show the influence of soil conditions until later.

The cuttings were all lifted during the following winter and recorded in the categories A., G., and D., and twelve grown cuttings from each unit of fifty cuttings were set aside for dismemberment and weighing. Each sample batch was divided into five parts as under :

1. Primary shoots ....shoots arising directly from the original cutting.
2. Secondary shoots ..all shoots other than primary.
3. Base roots .....roots arising from base of cutting.
4. Side roots .....roots arising along the original cutting.
5. Carcase .....the original cutting now enlarged by secondary thickening.

Each of the five sections was placed in a container and dried to constant weight at 100° C. for weighing. The percentages of cuttings rooted (stand) and dry weights per cutting are set out in Table III, alongside those obtained in the following year.

TABLE III.

STAND OF CUTTINGS AND DRY WEIGHT OF PRIMARY SHOOTS (SAMPLES) AT LIFTING.

Soil.	Part of Shoot.	1944. % Rooted.	1944. Primary shoots. Dry weight in gm. per cutting.	1945. % Rooted.	1945. Primary shoots. Dry weight in gm. per cutting.
MYROBOLAN B :					
Malling loam ..	Basal.	89	**6·10***	32	**15·80**
	Middle.	70	**5·83**	42	**7·97**
Lake soil	B.	93	**6·58**	59	**6·45**
	M.	47	**5·02**	83	**3·97**
Bagshot sand ..	B.	70	0·94	52	**4·90**
	M.	48	1·08	82	**6·22**
Bagshot black sand	B.	72	**3·15**	82	0·72
	M.	32	**4·98**	50	0·70
BROMPTON :					
Malling loam ..	B.	33	**3·06**	13	1·7
	M.	35	2·77	36	2·07
Lake soil	B.	78	**6·10**	26	1·17
	M.	67	**5·37**	17	0·80
Bagshot sand ..	B.	11	0·63	33	1·95
	M.	8	0·73	35	2·10
Bagshot black sand	B.	35	1·54	2	—
	M.	32	1·48	2	—

* **6·10** = Dry weight of primary shoots exceeding 3 grammes, shown in heavy type.

Since the figures shown in the Tables were in transformation when they were dealt with statistically, significant differences cannot conveniently be given. However, all assertions relating to differences have been justified by means of analyses of variance showing levels of significance of one in twenty or beyond. Root/shoot ratios were not statistically analysed.

In 1943-4 the stand of Myrobolan B nowhere fell much below 50 per cent., except on the black sand and then only with the middle cuttings which, on all four soils, behaved less well than the basal cuttings. The growth, as shown by dry weight of primary shoots, varied considerably from soil to soil. In general, a mean dry weight of less than 3 grammes for the primary shoots means that the cuttings have made insufficient growth for immediate use for tree raising and must remain unworked

for a further season to attain size. On this reckoning the growth on the ordinary Bagshot sand was most unsatisfactory, with that on the black sand considerably better, though less than on the Malling loam and lake soils. Fig. 1 shows the product of a unit plot of Myrobolan B in 1944 from each soil for comparison.

The Brompton cuttings, except on the typical sand, rooted well for the variety and on the lake soil made excellent growth. In both Myrobolan B and Brompton on the typical Bagshot sand there was damage to the base of the cuttings which was attributed to waterlogging, though it was not possible to prove this.

Second Trial, 1944-5.

This second trial was recorded in the same way as the first. The May census revealed that all the cuttings were in a fairly satisfactory condition, as judged by above ground appearance, except for the Myrobolan B basal cuttings on Malling loam and Brompton middle cuttings on black sand. The values are shown beside those of the previous year in Table II.

The following winter the cuttings were lifted and samples were dismembered and weighed as previously described. The weights are shown in Table III. The outstanding feature was the extremely poor performance of the cuttings in the black sand and, though the stand of Myrobolan B was quite satisfactory, the growth was almost negligible. In respect of stand of Myrobolan B, on Bagshot sand the middle did better than the basal but, on the black sand, basal gave the better stand. The cause of this behaviour is not evident. The second notable fact is that the Bagshot sand, a higher site than in the previous year, gave a good stand and growth of Myrobolan B and proved at least as good as any other soil for Brompton in that year. Still another interesting observation is that in general the relative performance of basal and middle cuttings is reversed in the two years. In the second year the growth in Bagshot sand was better than on black sand for both varieties. The reversal of performance on the two Bagshot soils in the second season becomes less confusing when it is realized that the water conditions were also reversed. In the first trial the normal sand was inclined to be waterlogged and the black sand dry. In the second trial the black sand was definitely waterlogged and the normal sand was well drained.

Shoot/Root Ratio.

The values obtained by setting the total weight of new shoots over the weight of roots are shown in Table IV. High root production per unit of stem, i.e. a low shoot/root ratio, is a feature of the Bagshot sands and other soils which do not encourage shoot growth (Rogers and Vyvyan, 1934) and within a plant variety, and for a comparable population, may be taken as indicating lack of soil fertility. The unusually low stand on Malling loam in 1945, by reducing root competition, probably accounts for the exceptionally high proportion of shoot to root in that year.

TABLE IV.

RATIO OF SHOOT TO ROOT OF MYROBOLAN B IN 1944 AND 1945 ON THE FOUR SOILS.

Soil.	Shoot/Root.		Percentage grown.	
	1944.	1945.	1944.	1945.
Malling loam	2·4	4·9	79	37
Lake soil	2·9	3·1	70	71
Bagshot sand	1·6	2·5	59	67
Bagshot black sand ..	2·1	2·0	52	66

Discussion.

When shoots are collected for cuttings they already possess certain definite qualities which, to a large extent, govern their reaction to conditions imposed upon them subsequently. While this is perfectly clear from variety to variety, and generally accepted by horticulturists, the same is true within the variety or clone. Within wide limits the imposition of different conditions of soil and environment fails to cloud the inherent properties of the cutting. This is seen in the ready rooting Myrobolan B, where, in the first trials, basal cuttings were definitely *superior* to middle cuttings, no matter in which soil they were planted, and in the second trials, disregarding the waterlogged black sand, the basal cuttings were definitely *inferior* in regard to stand of rooted cuttings. It is not known precisely why the cutting material behaved so differently from season to season, but it is clear

that the nature of the material was an important factor governing performance after planting. In this connection it is interesting to note that, in both years, the more typical sand plot was part of a larger plot planted with Myrobolan B cuttings collected at Bagshot and that, in both years, these cuttings rooted and grew less well than the cuttings within the experiment. This demonstrates clearly the contrasting behaviour of cuttings from different sources when planted and grown under the same conditions, and the very great importance of physiological condition of the parental material. While it is true that a given type of cutting will tend to behave in certain ways in differing soils, it is only by the use of uniform cuttings that the soils may be compared. Considering the two varieties separately, Brompton rooted and grew well in 1944, but poorly in 1945. It appears that, in favourable seasons on selected sites, this variety might be rooted from hardwood cuttings, but normally it is not a commercial proposition. Myrobolan B rooted and grew satisfactorily in both years, except on the ill-chosen sites on the Bagshot sand. The poor stand on Malling loam in 1945 is contrary to general experience over the last ten years. The trials show that the degree of success depends upon the choice of the site. Malling loam and the lake soil are generally suitable, but in the variable Bagshot sands area the site should be most carefully chosen. The higher site used in the second trial yielded quite satisfactory returns, but a somewhat similar soil at a lower level proved quite unsuitable. The so-called black sands also gave strikingly different results. One, at the high level, gave fairly satisfactory results with both varieties, but at the lower level, where the black sand was waterlogged, the Myrobolan B remained extremely small and the Brompton all but died out.

It seems, then, that rootstock raisers on the Bagshot sands can expect satisfactory results in propagating Myrobolan B from October planted cuttings provided they avoid low lying sites. These sands engender a high root/shoot ratio and for this reason the material should behave well after transplantation. It also appears, from the poor performance of cuttings collected and planted at Bagshot alongside one of the experimental plots in each year, that the source of the cuttings is of considerable importance and this merits further investigation.

Acknowledgement.

Thanks are due to Messrs. W. Fromow & Sons of Windlesham, for permitting the use of their land and for the help and consideration so generously given during the investigation. The help of the Statistical Section of the Research Station in analysing the data collected is also gratefully acknowledged.

Summary.

Hardwood cuttings of the ready rooting Myrobolan B and the somewhat shy rooting Brompton, each of two grades, collected from plants grown on Malling loam, were planted on four soils : Malling loam, a dry lake bed soil, and two Bagshot sands in each of two years. The results show that the loam and lake soil were satisfactory, but that the performance on the Bagshot sands depended upon choosing a site free from waterlogging.

The Myrobolan B rooted well in all but the poorest situations, but the rooting of Brompton proved inadequate.

There was a higher proportion of root in the material propagated at Bagshot.

The poor performance of cuttings collected from plants grown at Bagshot and planted alongside the plots on the sands, indicated the great importance of source (or internal condition) of cuttings.

References

Garner, R. J. (1943). "Raising rootstocks." *Rep. East Malling Res. Sta. for 1942*, 84-90.

——— (1944). "Propagation by cuttings and layers. Recent work and its application with special reference to pome and stone fruits." *Imp. Bur. Hort. and Plant. Crops. Tech. Comm.* **14.**

———, and Roach, W. A. (1945). "Comparative susceptibilities of certain horticultural and agricultural plants to trace element deficiencies." *Rep. East Malling Res. Sta. for 1944* (1945), 70-3.

Knight, R. C., and others (1928). "The vegetative propagation of fruit-tree rootstocks." *Rep. East Malling Res. Sta. for 1926 and 1927*, II Suppl. (1928), 11-30.

Rogers, W. S., and Vyvyan, M. C. (1934). "Root studies. V. Rootstock and soil effect on apple root systems." *J. Pomol.*, **12**, 110-30.

Sinha, A. C., and Vyvyan, M. C. (1943). "Studies on the vegetative propagation of fruit-tree rootstocks. II. By hardwood cuttings." *J. Pomol.*, **20**, 127-35.

A WINTER PRUNING TRIAL OF PEARS

By T. N. HOBLYN

(Report on an Experiment carried out by the late Mr. J. Amos.)

Introduction.

One of the first research projects started at East Malling was an experiment on the winter pruning of apples. In this, the natural habit of a wide range of varieties, as shown by the wholly unpruned tree, was compared with the growth and cropping of trees receiving increasingly severe pruning treatments. These ranged from simple regulation, or branch thinning, to leader-tipping combined with short-spurring of the laterals ; the form of the trees being the same for all, that known as " open centre " (Grubb, 1923).

A few years later a similar trial was commenced on pears by the late Mr. J. Amos. Again, a wide range of varieties was included. The treatments, however, were not quite the same as in the apple trial. No completely unpruned trees were included, but the " regulated " trees enabled the natural habit of the varieties to be studied, without some of the drawbacks of no pruning. Two treatments, both involving leader-tipping, were included (1) the " modified leader ", in which the centre of the tree was kept filled by encouraging the growth of a central leader ; this was combined with " long-spurring " of the laterals (to three good buds) ; (2) " open centre ", in which the centre of the tree was kept open ; this was combined with " short-spurring " the laterals (to one good bud).

The preliminary results of this trial were described by Amos (1928). As in apples, tipping the leaders always delayed blossom formation, and while the tipped trees made more growth of young wood, the untipped trees had a larger stem girth. However, on the whole, short-spurring the laterals did not lead to excessive growth, as is usual in apples and, although the production of terminal and axillary fruit buds was shown to be a varietal habit, in the majority of varieties, hard-spurring the laterals did not prevent the production of potential blossom buds. This trial was not continued for very long after this first report, partly because of the tendency of several of the varieties worked on quince to scion root, not yet realized when these trees were planted with their unions at or below ground level. Also the trees were interplanted between half-standard plums and, although these were removed at the end of 1930 when the pears were eight years old, many of the pear trees had been " drawn up " by the plums and were not very suitable for further pruning comparisons. Nevertheless, sufficient had been learned from this preliminary trial to enable its successor to be planned, and trees for this were ready for planting in the spring of 1931.

Situation.

The new plantation, which covered about an acre of land, was established on the site of an old hop garden, which had been previously devoted to comparisons of fairly heavy dressings of organic manures. The land was therefore in good heart. The plantation was in a rather low-lying situation and might have been expected to be particularly liable to frost damage. It has not, however, been any more damaged by frost than any other plantation, and since full bearing started in 1939 until the end of 1945, the trees have cropped heavily in five out of seven years.

The trees were planted at 12 ft. square. As will be seen, this close planting, while resulting in heavy yields per acre, has led to complications as the trees grew older, since the plan did not allow for thinning the trees. From the point of view of the present trial, the inclusion of nine varieties, made possible by close planting, has probably justified this intensive use of the ground, especially as the trial has yielded its main results before the need to thin the trees became urgent ; nevertheless, if the trees had been so arranged that, for example, half the replicates could have been removed, when the trees became too close, the remainder might have been used for further experimental treatments and the life of the plantation usefully extended. In more up to date designs the possibility of superimposing additional treatments on the primary experiment is always allowed for, if possible.

In the first nine years, from 1932-40, the trees were intercropped with red currants, a crop which did not interfere greatly with the needs of the pears.

Varieties.

Nine varieties were selected for trial, including most of those commonly grown in commerce at the time ; all of these were known to be compatible with Quince A, on which all were single worked. Varieties not compatible with quince were omitted so as not to over complicate the trial

with rootstock differences. There is little evidence of scion rooting in this trial except, possibly, in Doyenné du Comice. One tree of Emile d'Heyst is very much larger than its fellows, but as it has not been possible to prove that the roots are not quince, it has been included in the results. The following list sets out the nine chosen varieties and their main characteristics :—

Variety.	Vigour.	Habit.
Beurré d'Amanlis	Vigorous	Spreading.
Catillac	Vigorous	Spreading.
Conference	Moderate	Intermediate.
Doyenné du Comice	Moderate	Very upright.
Durondeau	Weak	Intermediate.
Emile d'Heyst	Moderate	Upright.
Fertility	Moderate	Upright.
Beurré Hardy	Very vigorous	Upright.
Pitmaston Duchess	Very vigorous	Upright.

All trees were planted as 2-year-olds in the spring of 1931 and for the first two years after planting were pruned alike.

Pruning Treatments.

In the spring of 1934, several leading pear growers were invited to come to East Malling and give their views on the pruning problems then confronting the grower. At that conference, after the results of the earlier trial had been reviewed, it appeared that the main problem was that of tree shaping during the formative years. It was generally agreed that leader-tipping was necessary and that the " open centre " type of tree was the most desirable for the climate of south-eastern England. Here agreement ended, for the recommendations varied from a tree formed by reducing the number of leaders to a minimum and tipping these hard, at any rate in the early years, to a tree formed by leaving a larger number of branches and tipping them lightly until the main framework of the tree was formed. In the former, it was thought that by restricting the number of branches and thus the number of fruit buds, fruit-set of shy bearing varieties might be improved. It was generally agreed that sufficient had been learnt about the habit of the different varieties to dictate the treatment of the lateral growths and that this should not form part of the experiment.

As a result of this discussion four treatments of the branches and leader growths were decided on :—

1. Few Branches. Hard Leader-tipping.
2. Few Branches. Light Leader-tipping.
3. Many Branches. Hard Leader-tipping.
4. Many Branches. Light Leader-tipping.

The difference in number of branches varied with different varieties and tended to become less as the trees grew older.

In March, 1937, after the treatments had been in progress for three years, on the average for all varieties, 39 leading shoots were allowed to remain after pruning on the trees with " Many Branches ", while on those with " Few " the number was 28. As an example of varietal differences, on the strong growing spreading variety Beurré d'Amanlis the numbers of leaders left were " Many " 53 and " Few " 35, but for the weak growing Durondeau the comparative numbers were " Many " 31 and " Few " 21.

The degree of leader-tipping also varied with the variety and, to some extent, from year to year. On the average Beurré d'Amanlis, Conference, Doyenné du Comice, Catillac and Fertility had two-thirds removed from the hard-tipped trees and one-third from the lightly-tipped trees annually until 1945. Beurré Hardy and Pitmaston Duchess had similar proportions removed until 1941, when leader-tipping ceased altogether for these two varieties. The weaker growing Durondeau was cut rather harder, the proportions cut off being three-quarters and one-half. Emile d'Heyst was tipped the same as the majority until 1936, after which the amount from the hard-tipped trees was increased to three-quarters.

In 1941, all varieties were dehorned into 2- or 3-year-old wood " where necessary ". In practice, this applied chiefly to the more vigorous varieties and, as will be seen, it was necessary to remove considerably more from the lightly pruned trees. In 1943, all trees were " set up " to facilitate cultivation. By 1945, it was again necessary to dehorn most of the lightly pruned trees. Owing to labour shortage and an early season, however, it was not possible to complete this process until the spring of 1946.

No differential lateral pruning was included in the experiment, all trees of each variety being treated alike. Catillac were " long-spurred " throughout, i.e. laterals cut to three good buds. The vigorous Pitmaston Duchess and Beurré Hardy were also " long-spurred ", but each year about one-third of the laterals were left full length, being subsequently worked back. All other varieties were " short-spurred ", i.e. to one good bud, leaving short laterals with terminal fruit buds uncut.

Experimental Design.

The experiment was designed in eight randomized blocks, each block containing four rows of nine trees, with the following modification. Each variety occurred once in each row of nine trees. The treatments were so arranged that two only appeared alternately in each row to simplify pruning and recording. This method, while convenient from the point of view of pruning and recording the trees, was not very suitable at the close distance of planting, since varieties of very different habit and vigour arranged at random have now become badly crowded where two or more vigorous ones occur together, and no orderly method of tree thinning is possible.

The Effect on Growth.

(*a*) *Wood growth.*

For the first two years after the pruning treatments started all shoot growth was measured. At this stage there was practically no difference between treatments in the *total* shoot growth, but in the second year, the lightly-tipped trees made more but shorter shoots than the hard-tipped trees. The effect of the difference in number of branches allowed to develop started to show up in the number of leading shoots (before pruning), counted at the end of the third and fourth years as shown in Table I.

TABLE I.

AVERAGE NUMBER OF LEADING SHOOTS FOR ALL VARIETIES BEFORE PRUNING AT THE END OF 1936 and 1937.

	1936. Third season.	1937. Fourth season.
Few Branches—Hard-tipped	35	28
Few Branches—Lightly-tipped ..	37	32
Many Branches—Hard-tipped ..	43	47
Many Branches—Lightly-tipped ..	45	52

This effect was maintained by annually reducing the number of leaders on the " few branch " trees, while most of those on the " many branch " trees were allowed to remain. It will be noticed that there is a slight tendency, statistically significant in 1937, that was apparent in nearly all varieties, for the lightly-tipped trees to develop more leaders than the hard-tipped ones. This tendency is rather surprising, since usually the harder a tree is tipped the more shoot growth is made.

(*b*) *Weight of wood pruned off.*

The amount of wood removed at pruning time was weighed annually, 1-year-old wood and branches separately. As might be expected, for the first few years, rather more wood was removed from the hard-tipped than from lightly-tipped trees but, since the difference in treatment was confined to the leaders, the actual difference in weight was small.

By 1941, after seven years, the very vigorous upright varieties Pitmaston Duchess and Beurré Hardy all had to be dehorned ; and from this date all leader-tipping ceased for these two varieties. More wood was removed from the lightly-tipped trees than the hard-tipped ones. The difference due to pruning treatment at this date was much greater on the spreading varieties Beurré d'Amanlis and Catillac, the lightly-tipped branches of which had become over long and thin and had to be cut hard back. Four years later, the lightly-tipped trees of all varieties needed dehorning, either because of overcrowding or because the trees were too tall and the branches were becoming too slender.

The differences in amount of wood removed between the trees with many and few branches were surprisingly small though, when dehorning was carried out, rather more was cut from the trees with many branches. At the time of writing, however, the more upright varieties with many branches need considerable branch thinning in order to let light and air into the trees.

TABLE II.

AREA OF CROSS SECTION OF STEM IN SQ. CM. IN FEBRUARY, 1941, AFTER SEVEN YEARS DIFFERENTIAL PRUNING, OF ALL VARIETIES.

	Few branches. Hard-tipped.	Few branches. Lightly-tipped.	Many branches. Hard-tipped.	Many branches. Lightly-tipped.
Beurré Hardy	164	171	157	168
Beurré d'Amanlis ..	113	126	122	135
Catillac	98	116	95	113
Doyenné du Comice ..	88	108	97	114
Pitmaston	91	104	93	112
Fertility	85	90	81	102
Conference	64	74	70	74
Emile d'Heyst	51	62	57	56
Durondeau	49	51	45	50

(c) Cross Section of Stem.

Table II shows the average cross section of stem in sq. cm. measured 9 in. above ground level for all varieties and treatments in February, 1941, before any dehorning treatments had been done.

Summarizing these measurements for all varieties, Table III shows that on the whole the lightly-tipped trees had markedly larger trunks than the hard-tipped trees; this difference was highly

TABLE III.

MEAN CROSS SECTION OF STEM FOR ALL VARIETIES IN SQ. CM. FEBRUARY, 1941.

	Hard-tipped.	Lightly-tipped.	Mean.
Few Branches	89·2	100·2	94·7
Many Branches ..	90·8	102·7	96·7
Mean	90·0	101·4	—

significant. There was no significant difference between the trees with few and many branches. Although there seemed to be some difference in the response to tipping of different varieties, e.g. Catillac compared with Durondeau, statistical analysis showed that this interaction was not, in fact, significant.

(d) Height and Spread.

The height and spread of all trees was measured in the spring of 1945. However, by that time, as has been related, several varieties had been dehorned, so that in these varieties differences due to the original pruning treatments were to some extent masked. Little or no dehorning had been done to Conference, Doyenné du Comice, Durondeau or Emile d'Heyst, so that these four varieties illustrate the effect on tree shape well enough. The mean heights and spreads for the four varieties are shown in Table IV.

TABLE IV.

AVERAGE HEIGHT AND SPREAD IN METRES OF CONFERENCE, DOYENNÉ DU COMICE, DURONDEAU AND EMILE D'HEYST, MARCH, 1945.

	Height (m).			Spread (m).		
	Hard-tipped.	Lightly-tipped.	Mean.	Hard-tipped.	Lightly-tipped.	Mean.
Few Branches ..	3·45	4·10	3·77	3·10	3·70	3·40 }
Many Branches	3·39	3·72	3·55	3·26	3·85	3·55 }
Mean	3·42	3·91	3·66	3·18	3·77	3·47
	Sig. Diff.* = 0·14			Sig. Diff.* = 0·25		

* Sig. Diffs. (P=·05) between hard and lightly tipped trees apply also to differences between those with few and many branches.

On the whole, the effect of tipping was much more decided than that of number of branches, those tipped lightly being always taller and more spreading, but the difference in height was much greater on the trees with few branches. Trees with many branches were rather shorter than those with few, but the difference in spread was not significant. The difference in tree shape is shown diagrammatically in Fig. 1.

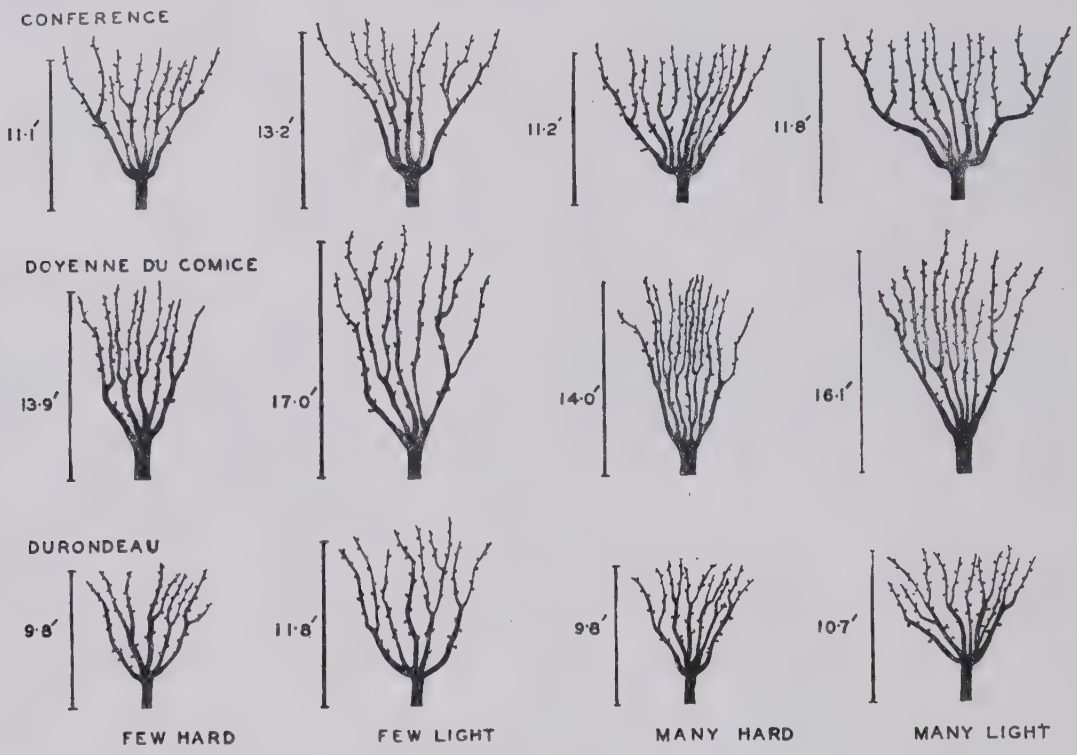


FIG. 1.

Conference, Doyenné du Comice and Durondeau after 11 years differential pruning showing relative size and shape of the trees. Average height in feet shown beside each tree.

Cropping.

(*a*) *Blossom Formation.*

The effect of hard and light pruning was soon apparent in the formation of fruit buds. These were counted annually for the first three years after the treatments started, and Table V shows the average numbers of blossom trusses per tree, formed during these three years, for all varieties.

TABLE V.

AVERAGE NUMBER OF BLOSSOM TRUSSES PER TREE FOR ALL VARIETIES, 1935-7.

	Hard-tipped.	Lightly-tipped.	Mean.
Few Branches	116	215	165·5
Many Branches ..	144	299	221·5
Mean	130	257	—

Sig. Diff. (P=·05) between Means, "Few" and "Many" or "Hard" and "Light" = 29·4.

Evidently the harder the trees were pruned the more fruit bud formation was delayed, but the effect of tipping was greater than that due to the difference in number of branches.

In the varieties that naturally form fruit buds readily, the absolute difference between hard-and lightly-tipped trees was large ; thus on Durondeau the numbers were, Hard-tipped 335 and Lightly-tipped 556. On the other hand, though the relative difference in the shy cropping variety Doyenné du

Comice seemed large, Hard-tipped 2 and Lightly-tipped 24 under both treatments the number of fruit buds formed was negligible.

(*b*) *Blossom Set.*

The object of restricting the number of branches was largely to improve blossom set in the early years. Some varieties, such as Pitmaston, normally produce many blossoms for several years before they bear a crop of fruit. Efforts to improve this " set " by other means have already been reported (Srivastava, 1938, Gayner, 1941). In the present trial, it was hoped that the fewer buds on the trees with a restricted number of branches would set more readily. In the event, the effect was very small, thus in 1939, Pitmaston, carrying about 980 blossoms on the trees with few branches and 1,140 on those with many, set 0·7 and 0·4 per cent. of them respectively ; and in 1940, when the number of blossoms was practically the same for both treatments, 1650 and 1670, the set on the " Few Branch " trees was 2·6 per cent. as against 1·5 per cent. on those with " Many Branches ". Thus it appears that the smaller number of branches carried more blossoms per branch and the set was not very different in consequence.

The effect of tipping on blossom set was more definite. Table VI shows the number of blossom trusses and percentage of flowers set on sample trees of three varieties, hard- and lightly-tipped, in 1939 and 1940. The number of flowers was calculated on the assumption of an average of five blossoms to a truss, a low estimate, so that the actual percentage set was probably lower.

TABLE VI.

NUMBER OF BLOSSOM TRUSSES AND PERCENTAGE OF FLOWERS TO SET FRUIT OF THREE VARIETIES IN 1939 AND 1940.

	1939.		1940.	
	Blossom Trusses.	Percentage Set.	Blossom Trusses.	Percentage Set.
BEURRÉ D'AMANLIS :				
Hard-tipped	1033	10·7	248	36·4
Lightly-tipped	1537	8·9	492	21·0
CONFERENCE :				
Hard-tipped	226	12·5	302	15·6
Lightly-tipped	563	7·2	699	13·1
PITMASTON DUCHESS :				
Hard-tipped	805	0·9	920	2·5
Lightly-tipped	1346	0·3	2406	1·7

Evidently the hard-tipped trees generally set more blossoms, but this did not by any means compensate for the larger number of fruit buds on the lightly-tipped trees, while the set of fruit on a slow cropping variety, such as Pitmaston, was under either treatment small.

(*c*) *Fruit.*

The cropping of this plantation as a whole from the point of view of yield per acre has already been described (Hoblyn, 1944). In that account, the cropping of the nine varieties in the trial was compared, with particular reference to time of coming into bearing. In the present report, the cropping is considered in two periods, 1936-40 (i.e. until the trees were 10 years old from the bud) and 1941 to 1945. The efficient use of the analysis of variance for testing the significance of the results of an experiment depends on the variation being homogeneous throughout the experiment. Where the actual crop of one variety differs greatly from the remainder this is not so. Therefore, in analysing the cropping of this trial, Doyenné du Comice, with a very much lower yield than the remainder in the first period, had to be omitted. In Table VII the yields of the nine varieties in pounds per tree are compared irrespective of pruning treatment.

In the Table the varieties are arranged in order of cropping, non-significant differences being bracketed. The Table needs little comment, such varietal characteristics as the early bearing of Beurré d'Amanlis and Fertility, heavy crops of Conference, Beurré Hardy and Catillac in the second period, and slow bearing of Pitmaston Duchess and Doyenné du Comice being evident. The trees of Durondeau are much smaller than the rest which accounts for the comparatively low crop.

Table VII.

Relative Yields of Nine Varieties in Pounds per Tree.

Variety.	1936–40. 6th-10th year.	Variety.	1941–5. 11th-15th year.	Variety.	Total 1936–45.
Beurré d'Amanlis (B.A.)	315	B.H.	407	B.A.	719
Fertility (F.)	246	B.A.	403	F.	612
Conference (Con.)	142	Con.	397	Con.	538
Catillac (Cat.)	137	Cat.	376	Cat.	513
Emile d'Heyst (E.H.)	96	F.	366	B.H.	492
Beurré Hardy (B.H.)	85	P.	320	P.	393
Durondeau (D.)	78	D.	159	E.H.	254
Pitmaston Duchess (P.)	73	E.H.	157	D.	236
Doyenné du Comice (Com.) ..	(13)	Com.	(127)	Com.	(140)
Sig. Diff. P=·05*	17		36		47

* This does not apply to comparisons with Comice.

In Table VIII the effects of tipping and number of branches on eight varieties not including Doyenné du Comice are compared separately for the two periods and for the whole 10 years.

Table VIII.

Comparison of Effect of Hard- and Light-Tipping and of Few and Many Branches on Crop in pounds per Tree, of Eight Varieties.

Period.	Number of Branches.		Tipping.		Sig. Diff. P=·05.
	Few.	Many.	Hard.	Light.	
	lb.	lb.	lb.	lb.	
1936–40	136	157	122	171	9
1941–5	312	334	306	340	18
Total 1936–45.. ..	448	491	428	511	24

The fruiting of the trees with many and few branches is a reflection of the blossom formation, for, though in both periods the trees with many branches bore significantly more fruit, the difference was on the whole small; in fact, in the first period, the difference shown is largely due to the variety Beurré d'Amanlis, which cropped much more heavily on the trees with many branches.

The detrimental effect of hard leader-tipping was clear in both periods, though relatively less in the second. In the first period, the difference was greater in the heavier cropping varieties, as shown in Table IX, while in the second, the hard-tipped trees of Beurré d'Amanlis caught up and passed those more lightly pruned, possibly because the latter had by then been dehorned. It is noteworthy that in this period the lightly-tipped trees of Pitmaston Duchess were still markedly ahead, although all leader-tipping of this variety ceased in 1941. The cropping of Doyenné du Comice is also shown in Table IX. Neither treatment induced this variety to crop appreciably up to the

Table IX.

Effect of Hard- and Light-Tipping on Cropping of Five Varieties in Pounds per Tree.

	1936–40.		1941–5.	
	Hard-tipped.	Lightly-tipped.	Hard-tipped.	Lightly-tipped.
	lb.	lb.	lb.	lb.
Beurré d'Amanlis ..	275	356	424	380
Conference	101	183	355	437
Pitmaston Duchess ..	57	88	282	355
Durondeau	73	83	144	174
Doyenné du Comice ..	5	21	76	177

time the trees were 10 years old, and it was not until the thirteenth year that the lightly-tipped trees bore a bushel of pears (48 pounds) to a tree. None of the hard-tipped trees of this variety had borne a bushel of fruit in any one year up to the fifteenth.

(*d*) *Fruit Size.*

The influence of pruning on fruit size was small, except where there were large differences in the numbers of fruits to a tree, and even then it did not necessarily follow that the trees with more pears carried much smaller fruit. For example, in 1942, Catillac, hard-tipped, carried 336 pears to a tree which averaged 0·43 lb. each while the lightly-tipped trees bore 540 fruits, averaging 0·35 lb. each. On the other hand, in the same year, Conference lightly-tipped carried 502 pears as against 318 when hard-tipped, but the difference in size of fruit was not appreciable. No significant differences in fruit size associated with pruning were found in 1943 or in 1944.

Discussion.

As a result of various experiments and commercial experience, the methods now recommended for pruning apples are considerably lighter than those of a generation ago. This difference applies to the treatment of the leader and lateral growths and is designed to permit the development of fruit buds and maintain the supply. In pears, the production of an ample supply of fruit buds has never been a difficulty, even while the trees are still young ; the main trouble has been to induce the blossoms of certain varieties to set fruit. In this trial restriction of branch area combined with hard-tipping was tried, in the hope that fewer fruit buds might set more fruit. To a small extent this was successful, but not sufficiently to accelerate the cropping of a really slow yielding variety. All the evidence of this trial goes to show that the lighter the trees were pruned, especially in the treatment of the leaders, the more blossom they produced and the greater the yield of fruit. The degree of pruning must, however, be considered in relation to tree shape, otherwise the tree may not be able to support the crop of fruit. Therefore no one method of leader-tipping can be continued throughout the life of a tree. With naturally quick cropping varieties, light leader-tipping in the early years should give way to more severe cutting as the trees come into bearing, to maintain the strength of the branches, keep the height of the tree within bounds and, with very heavy cropping varieties, keep up fruit size. With slower cropping and more vigorous varieties after the first two or three years, tipping should be very light or even omitted altogether, until the trees start to bear. After this some measures will be needed to maintain the strength of the branches and it would seem better to accomplish this by dehorning periodically, as necessary, rather than to attempt regular leader-tipping.

Acknowledgement.

Although the writer has been closely interested in this trial from its start, and now places its history and results on record, the credit must be awarded to Mr. J. Amos, who was in his lifetime responsible for the conduct of the experiment and, until the trees became too large, always pruned them himself. As usual many members of the Pomology Section have at one time or another assisted in pruning and recording, while the writer gratefully acknowledges the assistance of his colleague, Mr. S. C. Pearce, in analysing the data amassed during the last fifteen years, and to Miss J. M. S. Thom for executing the diagram.

Summary.

1. A winter pruning trial of pears is described in which nine varieties were subjected to four differential pruning treatments for twelve years.

2. The pruning treatments compared Hard and against Light Leader-Tipping and Few with Many branches.

3. Light leader-tipping resulted in larger trees that came into cropping earlier and generally produced more fruit over the whole period, but failed to induce very early bearing in a slow cropping variety such as Doyenné du Comice.

4. Trees with a restricted number of branches produced nearly as much blossom as those with many branches and the difference in " fruit set " was not appreciable. Hard leader-tipping did increase " fruit set ", but not sufficiently to induce early bearing in varieties that normally blossom well but fail to set fruit.

References

GRUBB, N. H. (1923). "Winter Pruning Experiments with Apple Trees." *J. roy. hort. Soc.*, **47**, 139.

AMOS, J. (1928). "A Progress Report on Winter Pruning Experiments with Pear Trees." *Rep. E. Malling Res. Sta. for 1926 and 1927*, II Suppl., 65-71.

SRIVASTAVA, D. N. (1938). "Studies in the Non-Setting of Pears. Part I. Fruit Drop and the Effect of Cultural Practices." *J. Pomol.*, **16**, 39-62.

GAYNER, F. C. H. (1941). "Studies in the Non-Setting of Pears. Part IV. The Effect of Irrigation and Injection on the June Drop of Conference Pears." *Rep. E. Malling Res. Sta. for 1940*, 36-41.

HOBLYN, T. N. (1944). "The Production History of Three Experimental Pear Plantations at East Malling, 1921-43." *Rep. E. Malling Res. Sta. for 1943*, 71-7.

A PROGRESS REPORT ON BREEDING WORK WITH THE TREE FRUITS

By H. M. TYDEMAN

As it is hoped that, with the end of the war, a full-scale programme of fruit breeding may be resumed, the present seems a suitable opportunity to review the results already achieved and to indicate the lines along which it is hoped that future work may be developed. Although very little actual breeding was possible throughout the period of the war, we were fortunate in being able to continue to test material already raised and considerable progress in certain directions can be recorded.

Rootstocks for Apples.

By the end of 1939 it had been possible to reduce to 55 the 800 or more apple rootstocks from crosses between the Malling " Paradise " and varieties immune from Woolly Aphid. All these had proved very highly resistant to attack by the aphis after stringent entomological tests and were finally selected, after extensive pomological and propagation trials, as being the most likely to prove of commercial value (Crane *et al.*, 1936, and Tydeman, 1935, 1940). A preliminary indication of their probable vigour, when worked with scion varieties, was made possible by the ingenious technique devised by Beakbane and Thompson and a tentative grouping was attempted (Beakbane *et al.*, 1941). After a further five years trial in the propagation beds, it seemed desirable to discard all except 20. These have been rapidly increased and trees of Cox's Orange, Ellison's Orange, and Jonathan worked upon them and on standard Malling rootstocks have been planted out on three different soils for extensive field trials. The rootstocks finally selected for trial are as follows :

Tentative Grouping.	*Selected Rootstocks.*
Dwarfing	161, 328, 434, 665.
Semi-dwarfing	11, 151, 332, 425.
Semi-vigorous	10, 12, 259, 411, 671.
Vigorous	74, 319, 524, 605.
Very Vigorous	238, 304, 306.

Maiden trees of three varieties on Nos. 12, 74, 151, 161, 238, 524 and 605 were noted as having particularly well fibred root systems.

Another series of apple rootstocks which have now reached the stage of field trial all have Malling No. IX as one parent. While they have not been tested for resistance to Woolly Aphid, several of them promise to make most valuable new dwarfing and semi-dwarfing rootstocks. After several years detailed observation of the original thousand seedlings in the stoolbeds (Tydeman, 1933), the 38 most promising underwent preliminary nursery trials worked with Cox's Orange and Lane's Prince Albert. The 18 rootstocks finally selected range from very dwarfing to very vigorous and all propagate easily (Tydeman, 1943). For a final trial under plantation conditions, trees of Cox's Orange, Sunset, Orleans Reinette, Egremont Russet and Ribston Pippin worked upon these 18 rootstocks have been prepared, while a duplicate set has been sent to the Horticultural Research Station at Wageningen, Holland, for trials under Continental conditions.

It seems unlikely that there will be any need to raise fresh apple rootstocks for a number of years to come, at any rate until the potentialities of the existing series have been fully explored. There are, however, a number of theoretical questions affecting the inheritance of vigour and other characters in apple rootstocks which will be investigated further as opportunity offers. These have been discussed in the various published papers.

Rootstocks for Pears.

While little actual crossing had been done among pears or quinces up to the period of the war, an intensive search was being made among material raised from seed imported from abroad for varieties likely to prove suitable as pear rootstocks. Seedlings from the Malling series of " Free " pears and from seed imported from North Caucasus failed to root satisfactorily in the nursery and after certain other studies had been carried out on them, they were discarded (Tydeman, 1939). Quince rootstocks from seed imported from the Caucasus have also been subjected to protracted study.

Some of these proved to be good rooters, although they were not superior in this respect to varieties already in commercial use. Where they were budded with varieties of pear incompatible with the commercial quinces, outstandingly compatible types were not found (Tydeman, 1938). A particularly interesting series of such imported quinces is still undergoing trial. They were notably dwarf growing in the nursery, although they rooted very freely. Clonal rootstocks from 15 selected seedlings were budded with Conference, which is normally compatible with quince, and Dr. Jules Guyot, which is generally incompatible. The trees are now in their fourth year and the following summary of their growth and blossoming on six of the selections, during three years, illustrates the extent to which pears may be dwarfed by the use of such quinces.

TABLE I.

PERFORMANCE OF CONFERENCE AND DR. JULES GUYOT PEARS ON SELECTED QUINCE ROOTSTOCKS.

Seedling No.	CONFERENCE. (Averages of Four Trees.)				DR. JULES GUYOT. (Averages of Four Trees.)			
	No. of dead trees.	Three years wood growth in metres.	No. of fruit buds.	Fruit buds per metre of new wood.	No. of dead trees.	Three years wood growth in metres.	No. of fruit buds.	Fruit buds per metre of new wood.
9 ..	0	8·2	127	15	1	0·5	28	56
1 ..	0	14·9	73	5	0	2·0	52	26
3 ..	0	17·8	100	6	0	2·5	72	28
4 ..	0	18·8	126	7	0	5·0	104	21
8 ..	0	19·6	178	9	1	6·4	136	21
14 ..	0	22·5	111	5	0	10·2	160	15
Malling A.	0	29·2	47	2	0	12·1	188	15
Malling C.	0	23·4	232	10	1	10·2	157	15

With the return of more normal conditions, it is hoped to resume the attempt to evolve an improved series of rootstocks for pears. Although, after extensive trials with many seedling quinces, stocks on which the so-called incompatibles will grow satisfactorily have not been found, it is probably worth continuing to search for them. Vegetatively propagated pear rootstocks are likely to prove better for this purpose, however, if they can be obtained, and the main emphasis in future work will be placed on efforts to produce such races by the continued selection and interbreeding of the most ready rooting individuals from families of wild pear seedlings.

Rootstocks for Plums.

Attempts to produce improved rootstocks for plums have not so far proved outstandingly successful. Of the numerous crosses between varieties of the *domestica* plums and between *domestica* and nearly related species, none has given seedlings showing much promise of being easy to propagate vegetatively. Imported *Prunus divaricata* seedlings tested over several years did not prove of outstanding merit, and were discarded (Tydeman, 1934, 1937).

There are several reasons why breeding work with plums has been somewhat slower than that with apples and pears. The fact that the pollination of a single plum flower produces only a single seed, instead of up to ten as in apples and pears, has meant that, with limited resources, large families have not been possible, while, in certain instances, difficulties have been encountered in germinating plum stones satisfactorily. Apart from these technical considerations, however, it has proved almost impossible to obtain plum and pear seedlings which will root adventitiously by the recognized nursery methods, although many have been tried. This is likely to be due to the scarcity or absence of the genes controlling this character in the varieties available as parents. Work with apples seems to indicate that such genes are cumulative in their effects and it is probable that the continued selection and interbreeding of the most ready rooting individuals in each generation will gradually evolve varieties which are easy to propagate vegetatively. At the same time progress would be greatly hastened if free rooting wild varieties could be discovered. Although they might not be otherwise suitable as rootstocks, such varieties would prove of great value as parents and a search is being made for them.

Scion Varieties of Apples and Pears.

When breeding work with apples and pears was started in 1929, an attempt was made by a programme of controlled crosses between established varieties to provide new kinds to meet recognized

needs. For instance, it was planned to extend the seasons of the popular dessert apples, Worcester Pearmain and Cox's Orange Pippin by the introduction of new varieties of similar flavour and appearance, but of different seasons or more robust habit.

Before much progress could be made in these directions, however, it was necessary to evolve rapid and efficient methods of growing and fruiting seedling apples and pears. The use of dwarfing rootstocks and framework grafting new seedlings on established trees to overcome the prolonged "juvenile" period have greatly shortened the waiting period between the germination of the seed and the time when the value of the resulting seedling as a potential new variety can be assessed (Tydeman, 1928, 1937).

Some promising new varieties have already been selected from the earlier crossings. Tydeman's Early Worcester (see page 121) may be regarded as the first result of the attempt to breed apples of the Worcester type but of different season, while there are several other promising apples of the same type still undergoing trial. It has not proved so difficult as was anticipated to transmit the typical "Cox's" flavour and one apple, Tydeman's Late Cox (see page 121), much later in season than Cox's and of a somewhat different appearance, has recently been recommended by the R.H.S. Fruit Committee for trial at Wisley. There are several others under trial in which some degree of the Cox's flavour is combined with an earlier or later season of ripening.

Observation has shown that, while certain crosses have given relatively few seedlings of value, others have produced large numbers of promising individuals. The cross between Worcester Pearmain and McIntosh Red has resulted in a high proportion of highly coloured, juicy apples of good flavour and appearance, while the double infusion of Cox's Orange "blood" involved in the cross between Cox's Orange and Laxton's Superb has been responsible for some seedlings of excellent flavour and quality. Similarly, some seedlings in which a measure of Cox's Orange flavour has been combined with earlier maturity have been derived from the cross between Cox's Orange and Ellison's Orange. It is too early yet to analyse finally the inheritance of the many characters in the numerous families of apple and pear seedlings at the Station, but the results so far obtained for apples indicate that their genetics are very complex (Tydeman, 1941, 1944).

Many of the 800 apple seedlings bred to provide rootstocks immune from Woolly Aphis attack, have now been fruited and worked as scion varieties on M. IX. As might have been expected the most promising new seedlings from the other point of view are being found in those families in which both parents are varieties grown for their fruit, as for instance Northern Spy × Worcester, Laxton's Superb or St. Cecilia, but some surprisingly good fruits have been obtained from families in which Spy has been crossed with the Malling rootstocks.

It is hoped to extend greatly work on the breeding of frost resistant varieties of apples in the near future. Several families bred specifically for this purpose are being fruited, while a careful watch is being kept for indications of frost resistance among seedlings raised for other objects. Of the varieties at present in cultivation, the flowers of some, such as Worcester Pearmain, Ellison's Orange, James Grieve and Wagener appear to possess an inherent resistance to spring frost injury and frequently escape partially when other varieties are completely destroyed. It is the very late flowering varieties which most usually escape damage, however, but of these only Crawley Beauty and Edward VII are recommended for commerce. There is every indication that such characters as season of flowering can be transmitted by breeding and an attempt will be made to produce frost resistant and late flowering varieties more suitable for general cultivation.

Since 1934 many pear seedlings from crosses between the better known varieties have been raised and are now being fruited. Several have already been selected as promising summer and autumn pears of good flavour and appearance. Both Clapp's Favourite and Louise Bonne de Jersey have proved useful parents, while crossed together they have given rise to several promising seedlings. All are being fruited on Malling Quince C; it is interesting that in almost all the families some of the seedlings have proved incompatible and have died.

Summary.

An account is given of work carried out during the past 17 years in raising and testing new apple, pear and plum rootstocks and scion varieties of apples and pears.

REFERENCES.

BEAKBANE, A. B., THOMPSON, E. C., and TYDEMAN, H. M. (1941). "Preliminary Selection of Apple Rootstocks based on certain Anatomical Differences in Root Structure." *Rep. E. Malling Res. Sta. for 1940*, 32-6.

CRANE, M. B., GREENSLADE, R. M., MASSEE, A. M., and TYDEMAN, H. M. (1936). "Studies on Resistance and Immunity of Apples to the Woolly Aphis, *Eriosoma lanigerum* (Hausmann *J. Pomol.*, **14**, 137-63.

TYDEMAN, H. M. (1935, 1940). "Apple Rootstocks Immune from Woolly Aphis. I. A Progr Report on Trials with New Varieties." *Rep. E. Malling Res. Sta. for 1934*, 115-22; II. T Testing in the Nursery of New Seedling Immunes." *Rep. E. Malling Res. Sta. for 19* 44-6; "III. The Influence of Four New Seedling Immunes on Lane's Prince Albert." *R E. Malling Res. Sta. for 1939*, 46-8.

——— (1933). "Breeding Experiments with 'Paradise' Apple Rootstocks." *J. Pomol.*, 214-36.

——— (1943). "Further Studies on New Varieties of Apple Rootstocks." *J. Pomol.*, **20**, 116-

——— (1939). "Pear Rootstocks from Seed. I. Experiments on Methods of Germinating P Seeds." *Rep. E. Malling Res. Sta. for 1938*, 103-109; "II. Studies on the Variation Seedling Pear Trees." *Rep. E. Malling Res. Sta. for 1938*, 110-14.

——— (1938). "The Wild Fruit Trees of the Caucasus and Turkestan. Their Potentialities Rootstocks for Apples and Pears. I. A First Report on some Wild Quince from Caucasus." *Rep. E. Malling Res. Sta. for 1937*, 103-16.

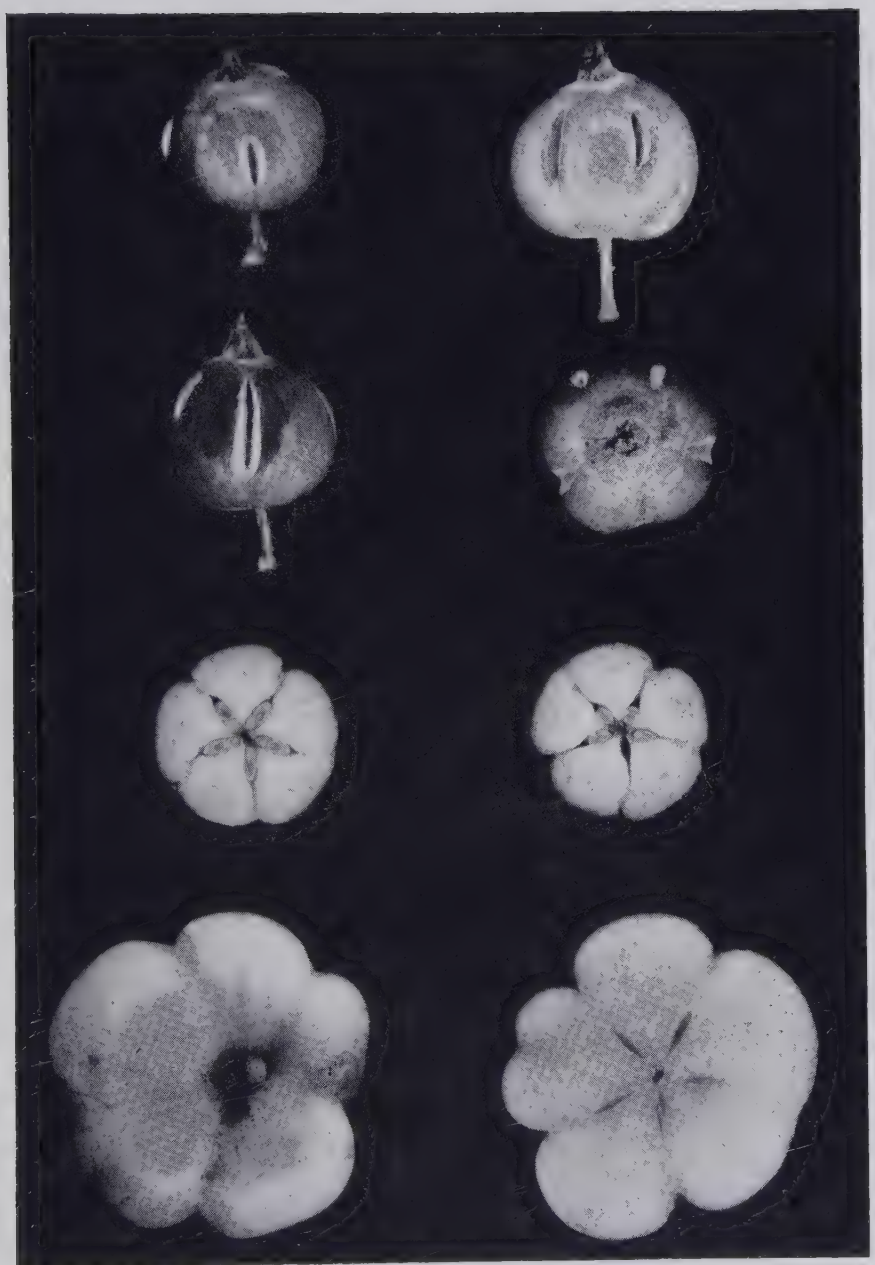
——— (1934, 1937). "New Varieties of Rootstock for Plums. I. A Preliminary Report on Tri with Seedlings of *Prunus divaricata*." *Rep. E. Malling Res. Sta. for 1933*, 100-2; "II. Final Report on seedlings of *Prunus divaricata*." *Rep. E. Malling Res. Sta. for 1936*, 100

——— (1928). "The Influence of Rootstocks on the Blossoming of Seedling Apples." *Rep. Malling Res. Sta. for 1926-7*, II. Suppl., 51-5.

——— (1937). "Experiments on Hastening the Fruiting of Seedling Apples." *Rep. E. Malla Res. Sta. for 1936*, 92-9.

——— (1944). "A Preliminary Account of Experiments in Breeding Early and Midseason Desse Apples." *Rep. E. Malling Res. Sta. for 1943*, 34-42.

——— (1941). "The Inheritance of Susceptibility to Sulphur Damage in Families of Seedli Apples." *J. Pomol.*, **19**, 137-45.



Photograph by Miss Eleanor C. Thompson.

Fig. 1.

First three rows show damage to young fruitlets (full size). Bottom row shows damage persisting on mature fruits (half size). Variety Worcester Pearmain.

(See page 75)

Fig. 2
Tree showing foliage and growth typical of Duquesnia.

Fig. 3
Tree showing foliage and growth typical of Mayetta.

VARIATION IN NON-CLONAL FRANQUETTE AND MAYETTE WALNUTS

By ELIZABETH M. GLENN

Introduction.

In 1926, eighteen young Walnut trees, nine said to be the variety Franquette and nine Mayette, were obtained from the Continent. Three of each were grafted on each of the following rootstocks:— *Juglans californica*, *J. nigra* and *J. regia*. Two of the Franquettes on *J. regia* were lost, and the remaining sixteen trees, after being in the nursery for two years, were planted as a rootstock trial, in their final position in open ground, in March, 1928.

A very few years later it became obvious that there was great variation, quite unconnected with any possible effect of rootstock, within these two varieties; and from careful examination of the size of the tree, habit of growth, foliage and fruits it was clear that the scion varieties were not clones.

Under these circumstances it was evidently impossible to show any but very large effects of rootstock, and indeed, apart from a possible size difference, none has appeared so far.

It is of interest, however, to record the variations which have been found in these varieties, since they are likely to be typical of those common in commerce on the Continent.

Standards.

The collection of Walnut varieties at the Station contains clones of the two varieties Franquette, obtained from California, and Mayette, from France; and since the characteristics agree closely with descriptions given by Howard Spence (1924) and Batchelor (1929), they have been taken as typical of the true Franquette and Mayette varieties.

They may be described as follows:

Franquette (index number P. 128). Nut, medium-large, long and with a pointed apex (see Fig. 1); shell fairly smooth, light coloured, a good quality nut. Tree vigorous, spreading, late leafing out, in the first or second week in May in an average year. Leaf medium-small, light green, with upturned margins, terminal lobe often twisted. Protandrous, the first catkins shedding pollen about ten days before the first stigmas are receptive.

Mayette (P. 11). Nut medium-large, long, with parallel sides and a blunt apex (see Fig. 1), shell fairly bright coloured and fairly smooth; a good quality nut. Tree vigorous, late leafing out, in the first or second week in May in an average year. Leaf dark green, with a large flat terminal lobe; head of tree appears dense owing to heavy foliage. Protandrous, the first catkins shedding pollen about a week before the first stigmas are receptive.

Variations in Franquette.

No tree is identical with the standard described above, although certain trees show a resemblance in some characters; for example, all are late leafing out, bud burst occurring in the first or second week in May in an average year, and all are protandrous, the catkins beginning to shed pollen about May 20th to 30th, and the first stigmas becoming receptive about a week or ten days later. A tree from this series showing typical Franquette foliage and habit is illustrated in Fig. 2.

Size of Tree and Habit of Growth.

Measurements of trunk girth, height and spread show the trees to be very variable in size. The largest tree has a height of 18 ft. and a spread of 25 ft., and the smallest has a height of 13 ft. and a spread of 13 ft. All have a spreading habit, and some have made very flat-headed trees.

The trees on *Juglans californica* rootstock have made rather larger trees on the average than those on the other two rootstocks, but the differences are not statistically significant.

Foliage.

Six of the seven trees have foliage that is typical of Franquette, except that two of them have darker green leaves than the standard. The seventh tree has very dark green leaves, although approximating to the standard in leaf size and shape.

Type of Nut.

Six of the trees have similar nuts, being very small, roundish but pointed, similar in some respects to a very short and small Franquette, but much too small to be considered a good nut. The seventh tree, which has the very dark green foliage, has much larger and longer, pointed nuts, nearer to the standard. (See Fig. 1.)

Crop.

The amount of crop so far has varied very much from tree to tree, and from year to year. Before 1942 the trees only bore a few nuts. In 1942 the seven trees bore a total of $3\frac{1}{2}$ lb. of green nuts. In 1943 they bore crops varying from 1 to $19\frac{1}{2}$ lb. of green nuts per tree, and in 1944, a frost year, from 0 to 13·7 lb. per tree. In 1945, when the trees were about 21 years old, they bore crops varying from 7·9 to 66·4 lb. of green nuts per tree.

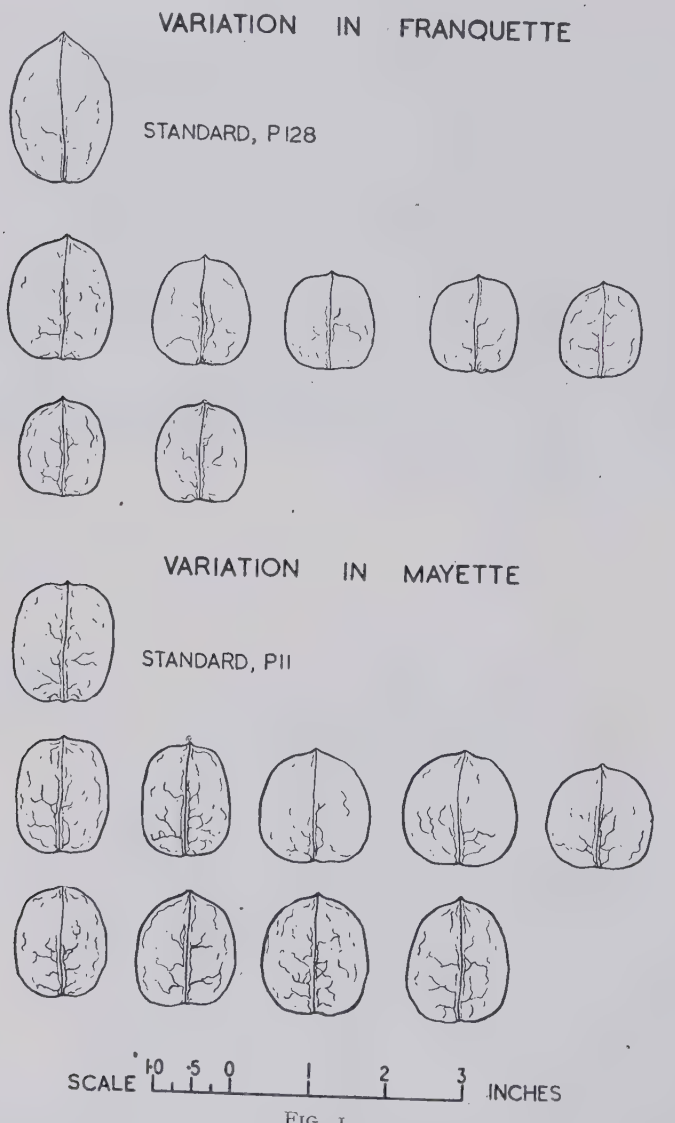


Fig. 1.

Variations in nut type in non-clonal Franquettes and Mayettes, compared with the standards for these two varieties.

Variations in Mayette.

As with the Franquettes, no tree is identical with the standard described above. In certain characters, however, some of the trees show a resemblance, and they are all late leafing out, bud burst occurring during the first or second week in May in an average year. A tree from this series showing typical Mayette foliage and habit is illustrated in Fig. 3.

Size of Tree and Habit of Growth.

The trees are very variable in size and shape, as shown by records of trunk girth and of height and spread. The largest tree has a height of 23 ft. and a spread of 24 ft., and the smallest has a

height of 15 ft. and a spread of 11 ft. Three of the trees are spreading, two are upright in growth, and the remaining four are intermediate in habit.

Foliage.

There is considerable variation between the trees in the colour, size and shape of their leaves. Three have heavy, dark green foliage which resembles the standard. The other six trees have smaller leaves varying from dark to light green in colour, three of them having small, light green leaves with upturned margins, which more nearly resemble those of the standard Franquette.

Time of Flowering.

Most of the trees produced only few pollen catkins until 1942, when they were 18 years old, but the smallest tree bore many catkins in the early years. One tree has never borne more than a few catkins.

Six of the trees are protandrous, the catkins first shedding pollen about May 20th to 30th, and the first stigmas becoming receptive about a week later.

Three of the trees are protogynous, the first stigmas becoming receptive about the end of May, and the first catkins beginning to shed pollen in the first or second week in June.

Two of these three trees with late catkins were very noticeable in 1938 and 1944, when spring frosts in the second week in May killed the catkins on the other trees as they were developing. Many of the catkins on these two trees, which were later and undeveloped at the time of the frosts, survived. In 1944 one of these trees had many catkins, which were shedding ripe pollen about May 30th. This tree produced 52 lb. of green nuts that year, when the heaviest crop from any other tree on the plot was 23 lb., and that was from the tree next to it in the row.

Type of Nut.

Two of the trees have nuts which resemble the standard ; but both have small, light green leaves.

The only three trees having foliage which resembles the standard, have medium-large nuts which are round but pointed, with a flattened base and smooth shell, similar in appearance to a Meylanaise. These are the three trees that are protogynous.

The remaining four trees have nuts of different intermediate types, two having fairly long and pointed nuts. (See Fig. 1.)

Crop.

Only a few nuts were borne before 1942, in which year the crops varied from very few to about 1 lb. of green nuts per tree. In 1943 crops varied from 2 to 35½ lb. of green nuts per tree and, in 1944, a frost year, one tree, having late catkins, bore 52·8 lb. of green nuts. Apart from this tree, the crops varied from 8·3 to 23·6 lb. per tree. In 1945, when the trees were about 21 years old, they bore crops varying from 10·5 to 68·1 lb. of green nuts per tree.

Conclusions.

From the above descriptions of the " Franquette " and "Mayette" varieties, as obtained from the Continent, it is evident that, at the time these were received, many of the trees grown under these names must have been of seedling origin, and that even when obtained as grafted trees the scions were by no means true to name. Although some trees correspond to the standard varieties in certain characters, in many instances the nuts themselves are small and of little commercial value.

Although trials have not been in progress long enough to show the extent of the variation in cropping of standardized clonal scion varieties, experience at the Station has shown that, at any rate in morphological characters, such as foliage and type of nut, they are very uniform.

Apart from the obvious undesirability of such material for commercial purposes, the trial described above illustrates, in relation to Walnuts, the lesson demonstrated so often with other fruit trees that it is futile to conduct experimental work, e.g., the trial of different rootstocks, with unstandardized scion material.

Summary.

Descriptions are given of the variation in habit, foliage, and nut type of Walnut trees obtained from the Continent as the varieties Franquette and Mayette. Comparisons are made with standard clones of the two varieties.

References.

Batchelor, L. D. (1929). " Walnut Culture in California." *Univ. Calif. Bull.*, 379 (revised).
Spence, Howard (1924). " Some Notes on Nut Growing in the Northern United States." *J. Pomol.*, 4, 1-23.

PROGRESS REPORT ON THE WALNUT VARIETY COLLECTION AT EAST MALLING

By ELIZABETH M. GLENN and A. W. WITT

Introduction.

Walnut research has been in progress at East Malling for 21 years. During this period some 120 varieties have been collected from all over the world. Witt (1938) gave a preliminary description of some of these varieties, including those then recommended as worth growing in Britain. Since then, two young plantations have borne their first crops and it is possible to bring up to date the tentative descriptions then given, to give some idea of time of leafing out, particularly in relation to spring frost injury, and conditions governing pollination and crop of the different varieties in these trials. It should be pointed out that these plantations are really collections of varieties, many of which are only represented by one tree, so that accurate statistical comparisons are not possible. Nevertheless some differences are so outstanding as to be worth putting on record.

Description of the Two Plantations.

Plantation A (known as Plot C6).

Between 1931 and 1934, young grafted walnut trees of several different varieties were planted in a chestnut spinney amongst the trees and undergrowth. A space was cleared for each tree, but all were shaded by the rest of the woodland and root competition was severe. It was hoped that, by planting the young walnuts in established woodland, the surrounding growth would protect them from frost damage. It was found, however, that owing to the rapid growth of the woodland trees, the walnuts were too shaded and drawn up, making badly shaped trees which failed to flower, and that the surrounding woodland gave no extra protection against frost. It was therefore decided to transplant the most promising varieties to a situation in the open.

The new site was well prepared before transplanting and, in March, 1941, 21 trees varying in age from 10 to 12 years, were carefully moved with the minimum delay. These trees were, in 1946, 15 to 17 years old.

The varieties in the plantation, 15 in all, include four French varieties, originally obtained from France ; four more French varieties and the variety Persian, obtained from America ; four English varieties selected from the prizewinners of the Royal Horticultural Society's competition in 1929 ; and two English varieties selected as suitable for pickling. The trees in this plantation were grafted on various *Juglans regia* and *J. nigra* seedling rootstocks.

Plantation B (known as Plot N4).

This plantation was established on an open site in 1934, when 2 to 4-year-old trees of seven English varieties grafted on *Juglans nigra* seedling rootstocks were planted. Five dessert varieties and two pickling varieties were included, two of the former and both of the latter being also included in Plantation A. These trees were, in 1946, about 14 years old.

The full list of varieties in both plantations, classified according to cropping, is given in Tables II and III.

Size of Tree.

The trees in Plantation A all recovered from transplanting, but made little growth in the first year, 1941. In 1942 they made some growth, and in 1943 they grew vigorously. They are now established and growing well. They show that it is possible to transplant walnut trees at 10 or 12 years old successfully, provided care is taken and they are replanted in their new position as soon as possible after lifting, so that the roots cannot dry out.

The trees in Plantation A, although the older, are smaller than those in Plantation B, possibly due to the check caused by transplanting.

Measurements of height, spread and trunk girth show that on both plots the variety Leeds Castle made the largest trees. In Plantation B this variety, at about 14 years old, made a tree 15 ft. high with a spread of 18 ft. The variety Excelsior of Taynton was nearly as large. The weakest growing variety, Champion of Ixworth, made a tree only 11 ft. high with a spread of 8 ft.

Time of leafing out.

The latest to leaf out in spring are the three French varieties Meylanaise, Mayette and Treyve. These normally leaf out during the first or second week of May. Leib Mayette, San José Mayette

and Franquette leaf out a few days earlier. The others, including the English varieties, leaf out about the middle of April. The different varieties leaf out in very much the same order each spring, although the actual dates of bud burst vary from year to year.

Frost damage.

In 1938 frosts were recorded on the nights of the 7th, 8th and 9th May, when the trees later included in Plantation A were still in the chestnut spinney. It had been a very early season, and the first trees had begun leafing out at the end of March. Many of the trees in the spinney had their terminal shoots damaged, but other shoots grew out and all the trees recovered. The two trees of San José Mayette were only slightly damaged; and Treyve, Mayette, Leib Mayette and Meylanaise were undamaged. The trees in Plantation B, in the open, had many of their terminal shoots slightly damaged.

In 1944, there were again frosts on the nights of the 7th, 8th, 9th and 15th May. The first trees had begun to leaf out in mid-April, and all developed leaves and shoots on the trees in Plantation A were killed. The trees had to commence leafing out again, and it was noticeable that, at this second bud burst, they tended to leaf out in the reverse order to normal. Those that were late leafing normally, and had only just commenced leafing out and so suffered very little damage, leafed out again almost at once. Those that had leafed out early had been badly damaged, and did not leaf out again for a week or a fortnight. The trees in Plantation B, which is on higher ground than Plantation A, suffered less.

Foliage.

The foliage is characteristic of the individual varieties, and varies from that of Lady Irene, which has very large, dark green leaves, to that of G.C.M.1., which has small, light green leaves with upturned margins. (See Table I.)

TABLE I.

Walnut Foliage.

	Large leaves.	Medium sized leaves.	Small leaves.
1. *Dark green. Leaves flat*	Persian† Lady Irene		
Leaves with upturned margins	Northdown Clawnut* Excelsior of Taynton* Meylanaise Treyve Glady	Secrett* Champion of Ixworth	
2. *Medium green Leaves flat*			
Leaves with upturned margins		Leeds Castle Patching	Stutton Seedling Franquette Mayette Leib Mayette San José Mayette
3. *Light green upturned margin*		Chaberte	G.C.M.1.*

* Leaves very red in spring.
† Leaves almost pure green in spring.
Other varieties: some red on the leaves in spring.

Most of the varieties have some red colouring on their young leaves and shoots in spring, the variety G.C.M.1. having very red young foliage. On the other hand Persian has very little red colouring, the young leaves and shoots are almost pure green.

These differences in foliage characters remain constant from year to year, and should serve as a means of identification.

Time of flowering: Pollination.

Some varieties have produced pollen catkins more consistently and at an earlier age than others, particularly Glady, Leib Mayette and San José Mayette, the first of which has produced catkins regularly since 1938.

The varieties Champion of Ixworth and G.C.M.1. have only borne pistillate flowers and no pollen catkins, while Persian has borne no flowers at all, either pistillate or staminate.

Of the trees that have borne pistillate and staminate flowers in the same years, seven varieties are definitely protandrous, the pollen catkins beginning to shed ripe pollen some days before the first stigmas are receptive. These varieties are Treyve, Franquette, Leib Mayette, San José Mayette, Northdown Clawnut, Lady Irene and Stutton Seedling. Six varieties are definitely protogynous—Glady, Chaberte, Excelsior of Taynton, Secrett, Leeds Castle and Patching.

In 1945, detailed records were taken on branches on four trees in Plantation A, of the time of ripening of the pollen catkins, and the times at which the individual clusters of pistillate flowers were receptive. (See Fig. 1.)

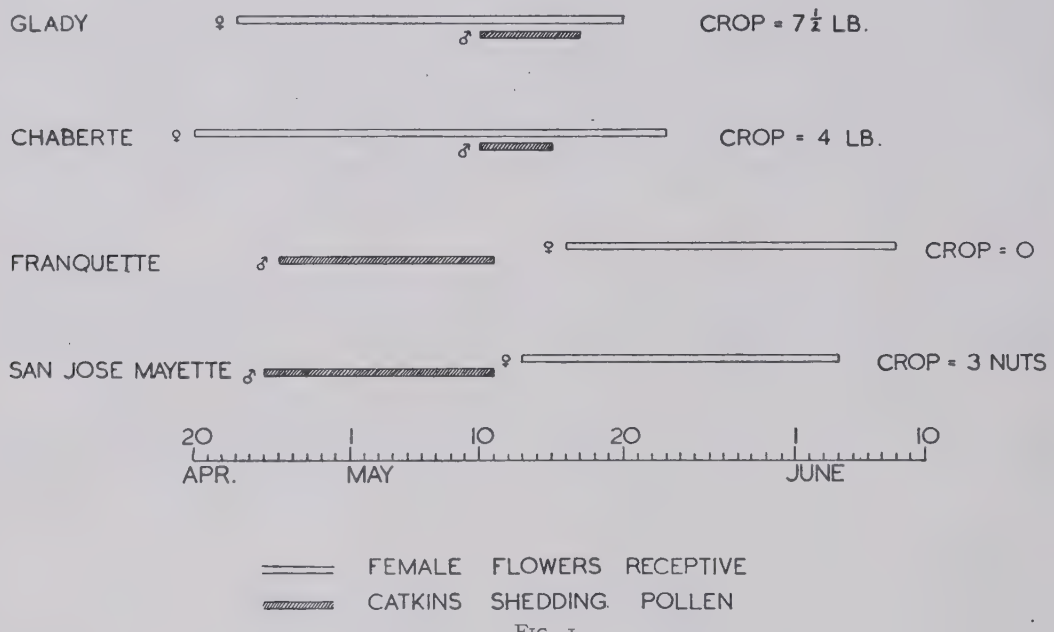


Fig. 1.

Flowering Periods and Crops of four Walnut trees in 1945.

Two of the varieties, Glady and Chaberte, were protogynous. In Glady the first stigmas were receptive on 23rd April, and the last on 20th May. The first ripe pollen was being shed on 10th May, and all the catkins had dropped by 17th May. In Chaberte the first stigmas were receptive on 20th April and the last on 23rd May. The first pollen was shed on 10th May, and all the catkins had dropped by 15th May.

In both varieties the pistillate flowers became receptive in succession over a period of about a month, individual pistils remaining receptive for 5 to 10 days. The first pollen was shed 17 and 20 days, respectively, after the first stigmas were receptive, and ripe pollen was shed for about a week. There were still sufficient pistillate flowers receptive when the pollen was being shed for a crop to be set on each tree. Only the later pistillate flowers set any nuts. The tree of Glady produced 7½ lb. of green nuts, and that of Chaberte produced 4 lb.

Both the other varieties, Franquette and San José Mayette, were protandrous. In Franquette the first pollen was shed on 26th April and all the catkins had dropped by 11th May, but the first stigmas were not receptive until 16th May. In San José Mayette the catkins shed pollen from 25th April till 11th May, and the first stigmas were not receptive until 13th May. In neither tree therefore was pollen being shed while the stigmas were receptive, so that the trees could not be self-fertilized, and bore no crop.

Crop.

Although the trees have not yet come into full bearing certain varieties appear to crop at a younger age than most. (See Table II.) In Plantation A Chaberte and Glady cropped well in 1943, two years after transplanting (i.e. at about 13 years old) and again in 1945. Only a few of the later leafing varieties—Meylanaise, Franquette, Mayette and Leib Mayette—bore one or two nuts in 1944, owing to spring frost.

TABLE II.

PLANTATION A.

Cropping—Total 1941-5.

Good (over 4 lb. per tree).	Moderate (1-3 lb. per tree).	Poor (very few nuts).	None
Chaberte Glady	Meylanaise Leib Mayette San José Mayette G.C.M.1 Northdown Clawnut Stutton Seedling Secrett Leeds Castle Patching	Franquette Mayette Treyve	Persian

In Plantation B (Table III) the varieties Northdown Clawnut and Stutton Seedling both cropped well in 1945, at 11 years from planting, averaging over 10 lb. of green nuts per tree. One tree of Stutton Seedling produced 30 lb. of green nuts.

TABLE III.

PLANTATION B.

Cropping—Total 1941-5.

Good (over 5 lb. per tree).	Moderate (1-5 lb. per tree).	Poor (less than 1 lb. per tree).	None
Northdown Clawnut Stutton Seedling	Excelsior of Taynton Leeds Castle Patching	Lady Irene	Champion of Ixworth

Notes on the more important Varieties.

English dessert varieties.

Northdown Clawnut.—Large nut of good quality and attractive appearance; crops well; a medium sized tree, which leafs out in mid-April, too early to be really safe from damage by spring frosts; distance of planting about 35 ft. apart. One of the best varieties for planting in generally frost-free situations.

Excelsior of Taynton.—Medium-large nut of good quality. Some nuts have been poorly sealed, but this trouble is common on young walnut trees and may disappear as the trees mature. A large vigorous tree, distance of planting not less than 40 ft. apart; one of the latest of the selected English varieties to leaf out, about the third week in April; protogynous, the catkins shedding ripe pollen while the pistillate flowers are still receptive.

Secrett.—Medium-large good quality nut of attractive appearance; a medium-large tree, which leafs out about the same time as *Northdown Clawnut*; protogynous, and has cropped moderately well.

These three are the best of the selected English varieties.

Stutton Seedling and *Lady Irene.*—Both these varieties are too subject to bacterial disease, which checks their growth and spoils the nuts. Stutton Seedling has been a rather variable but usually heavy cropper.

Champion of Ixworth.—A weak growing variety, making a small tree, which might be very useful for growing in a restricted space; but so far has borne no pollen catkins and has not cropped well; could possibly be planted as close as 20 ft apart.

English pickling varieties.

Leeds Castle.—A very large, vigorous tree; distance of planting 40 to 50 ft. apart; leafs out about mid-April; protogynous, producing catkins freely; moderate crops.

Patching.—A medium-sized tree, leafing out about mid-April, early ripening.

Neither variety has yet produced the large clusters of nuts that were borne by the original parent trees.

Other varieties.

Chaberte and *Glady*.—Both have medium-large double nuts of fair quality ; crop well, and at an early age ; both are protogynous, and produce pollen catkins freely, even at an early age ; distance of planting 35-40 ft. apart.

Franquette, Meylanaise, Mayette, Leib Mayette and *San José Mayette*.—The first two are selected seedlings obtained from America. The three Mayettes are also seedlings from this variety received from different sources. Descriptions of the original varieties have been given by Spence (1924), and Batchelor (1929), and trees apparently identical with these descriptions are included elsewhere in the Station's collection. None of these seedlings appears to be much improvement on the original. They are all late leafing out. A description of the variation that may be met with in Franquette and Mayette is included in this Report. (See p. 67.)

Persian.—Grows well and makes a large tree, but has not yet borne any pollen catkins or pistillate flowers ; may commence cropping when the trees are older.

Summary.

The progress of two plantations containing walnut varieties in the collection at East Malling is reviewed, with the results so far obtained on vigour, times of leafing out, frost damage, pollination and cropping. Descriptive notes are included on the more important varieties.

References.

Batchelor, L. D. (1929). "Walnut culture in California." *Univ. Calif. Bull.*, 379 (revised).

Spence, Howard (1924). "Some Notes on Nut Growing in the Northern United States." *J. Pomol.*, **4**, 1-23.

Witt, A. W. (1938). "A Survey of the Investigations on the Propagation and Testing of Walnuts at the East Malling Research Station." *Rep. E. Malling Res. Sta. for 1937*, 259-65.

CRACKING OF APPLES

By A. P. PRESTON

An unusual form of damage was observed on some young fruitlets of Worcester Pearmain, growing at East Malling Research Station, when they were the size of a halfpenny, during the first week in May, 1945. This consisted of from one to five longitudinal cracks upon the damaged fruits, a cross section of which showed that the cracks were always opposite a carpel. (See Fig. 1.) The fruits grew away quite healthily but the cracks persisted throughout the season. (See bottom row, Fig. 1.) Later in the season, Worcester Pearmain was seen to have cracked in a similar way upon several Plots on the farm, and the following varieties in the cordon collection were seen to be likewise damaged: Diamond, Opal, Kerry Pippin, Starks Delicious, Gravenstein and Devonshire Quarrenden. Only a small proportion of the crop was affected. Worcester Pearmain apples with similar damage were received in 1946, from Little Baddow, Essex, and Tenterden, Kent. But in that season no damage of this kind was observed at East Malling.

It is of course quite evident that this form of damage is distinct from the cracking caused by Scab and the common symptoms of " frost eye " and " frost ring ". It is interesting that this form of damage was not noted by members of the Research Station staff during their survey of farms made after the frost of May, 1935, when the familiar " frost eye " and " frost ring " were seen.

Summary.

An unusual form of damage observed on young fruitlets of Worcester Pearmain apple in 1945 is described.

WEATHER CONDITIONS DURING 1945

By H. M. TYDEMAN and A. P. PRESTON

THE general trend of the weather during 1945 was rather unusual in several respects. Somewhat dry conditions prevailed throughout the earlier half of the year and, by the end of June, more than an inch less rain than usual had been recorded. Sunshine, on the other hand, was unusually plentiful during this period and between the beginning of February and the end of July had exceeded the 30 years' average by 185 hours. April, in particular, was outstandingly sunny, with the unusually large total of 208 hours, or about 6½ hours per day. In spite of the plentiful sunshine, the weather was not exceptionally warm during April and early May and, for a few days at the end of April, very cold conditions with falls of snow were experienced. As may be seen from the accompanying diagram,* it was an early flowering season for all varieties of fruit, but, in spite of several ground frosts of moderate severity and the short period of very wintry conditions which occurred towards the end of the apple flowering season, only minor damage to strawberry flowers was recorded and excellent crops of all fruits were harvested in this particular locality, although widespread damage was reported from other areas.

The total rainfall for the year was 22·91 inches, considerably below the 30 years' average here. The only outstandingly wet month was December, although May and July were also a little wetter than usual. November was exceptionally dry, with less than a quarter of its expected total. The sun shone for a total of 1,589 hours during the year ; this was well above the average of the past 30 years. Only in September was sunshine seriously deficient.

Temperatures were rather low during the early weeks of the year, when severe wintry weather with prolonged snow was experienced. During the remainder of the year they followed a very normal trend and periods of exceptionally high or low temperatures were not recorded. Ground frosts were unusually prevalent, but fortunately those which occurred while the fruit was in flower were not sufficiently severe to do much harm.

* The writers' thanks are due to Mr. T. N. Hoblyn for permission to reproduce this diagram and to the members of the Statistical Section for assistance during the year.

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1945.

Month.	Temperature in Screen.					No. of Ground Frosts.	Rainfall.			Sunshine.			Soil Temperatures.		
	Mean Maximum.	Mean Minimum.	Highest.	Lowest.	Mean.		Total in inches.	Heaviest fall in a day.	30 years' average.	Total Hours.	Average per day.	30 years' average.	4 inches.	8 inches.	2 feet.
January	37	27	49	12	32	27	1·97	0·34	2·53	35·1	1·1	45·8	32·9	33·9	36·5
February	52	39	64	28	45	7	1·65	0·36	1·82	70·8	2·5	67·3	41·5	41·5	41·6
March ..	55	37	68	28	46	14	1·37	0·81	1·52	133·6	4·3	118·7	43·8	43·4	44·9
April ..	69	41	79	29	50	9	1·41	0·49	1·96	207·8	5·7	131·7	52·4	50·1	51·3
May ..	66	46	83	29	56	3	2·32	0·60	1·73	226·7	7·3	198·3	58·0	55·7	55·6
June ..	69	49	79	38	59	0	1·11	0·27	1·41	229·5	7·6	204·0	62·1	60·2	60·6
July ..	73	53	84	43	63	0	2·61	0·58	2·17	226·7	7·3	190·7	64·1	62·9	63·9
August ..	70	52	86	43	61	1	2·18	0·78	2·20	167·7	5·4	181·9	62·2	61·4	63·2
September	66	52	75	37	59	2	1·19	0·19	2·06	88·7	3·0	145·8	58·8	58·4	60·3
October	62	43	75	34	52	5	2·27	0·66	2·72	121·6	3·9	100·9	51·3	51·7	54·7
November	50	39	62	27	44	12	0·68	0·52	2·96	42·4	1·4	53·7	44·0	45·1	48·3
December	46	35	55	24	40	20	4·15	0·75	2·49	38·6	1·2	39·1	39·4	40·5	42·8
Totals						100	22·91		25·57	1589·2		1477·9			

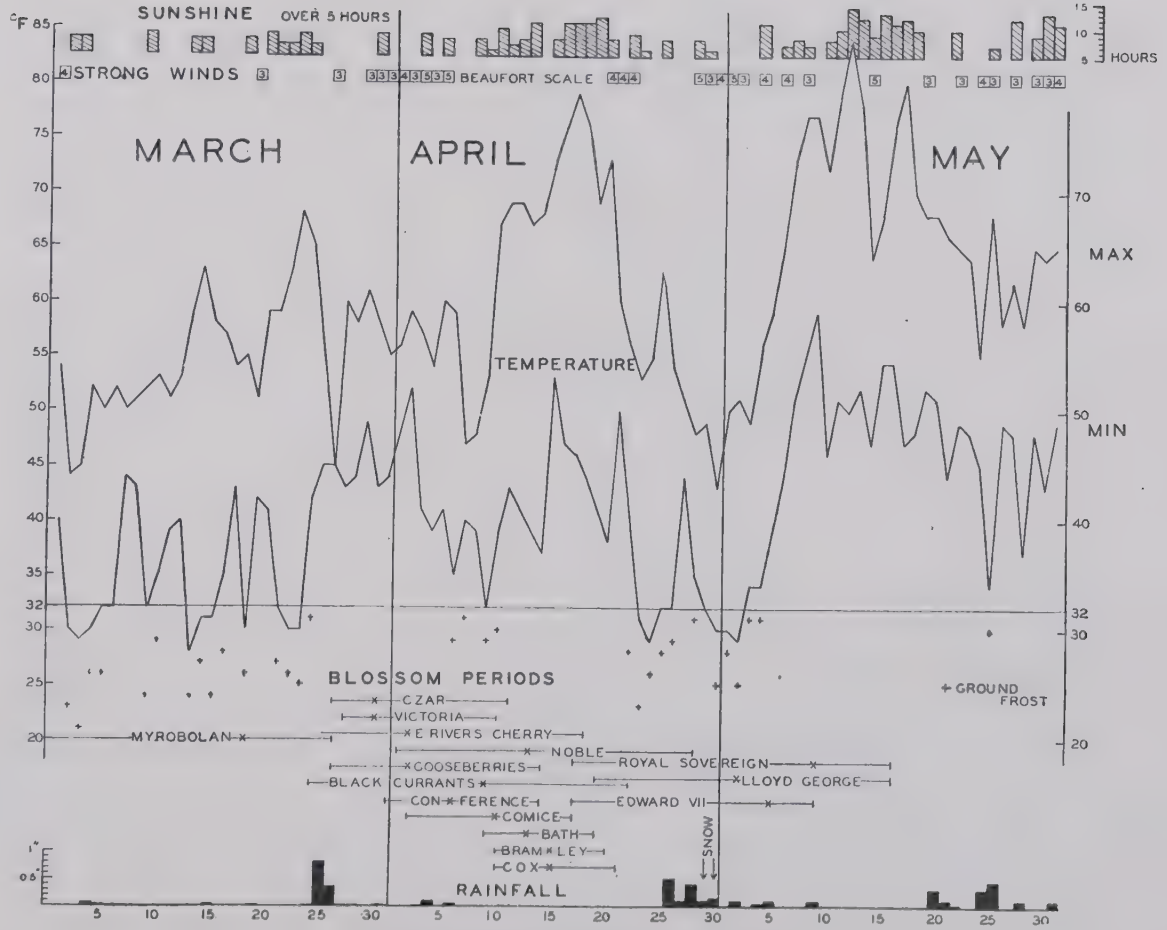


Diagram to show the weather recorded during the Blossoming Season of 1945.

PLANT PHYSIOLOGY

PROPAGATION OF FRUIT TREE ROOTSTOCKS BY STEM CUTTINGS

IV. EFFECTS OF SOIL CONDITIONS ON HABIT OF GROWTH IN MYROBOLAN B.

By M. C. VYVYAN and R. J. GARNER

Propagation by hardwood cuttings is one of the more convenient methods of raising rootstocks and is commonly used for certain varieties, such as the plum rootstock Myrobolan B. The value of the method, however, depends not only on the percentage of cuttings that root, but also on the quality of the resulting stocks. These must not be too small to bud ; coarse, heavily branched stocks, on the other hand, are both hard to bud and inconvenient to bundle-up for sale. It is known that soil conditions in the cutting beds may have a marked effect on the percentage of cuttings that root, but there is also evidence that they may have considerable effect on the quality of the resulting plants by influencing the size of the plants, their stem/root ratio and the branching habit. When selecting a suitable soil for a cutting bed it may be necessary, therefore, to consider its effect on the habit of the plant as well as its effect on the percentage that root.

An opportunity for obtaining further information on the effect of soil on the habit of growth occurred at East Malling in 1942. Two cutting beds of Myrobolan B had been planted on a commercial basis in the autumn of 1941 ; one on the normal soil,—loam overlying the Greensand,—of an experimental Plot on the Station, the other on the drained bed of the lake at Bradbourne,—a highly calcareous peat soil containing a definite peat layer at a depth of some 18 inches. (Garner and Roach, 1945.) The cuttings in both beds rooted well, but in the autumn of 1942 those in the bed on the drained lake seemed larger and more branched than those on the loam and there were indications that the stem/root ratio was also different in the two beds.

It was decided, therefore, to take samples of cuttings from the two beds and to determine their mean weights and the relative proportions of trunk,* branches and roots.

Methods.

Ten random samples of ten cuttings were taken from each cutting bed. For this purpose the bed on the lake soil was divided into five blocks each consisting of three adjacent rows 90 feet long, in the same way the bed on the loam was divided into five blocks of two rows 150 feet long. Two " starting points " were selected at random in each block and the next ten living cuttings were dug up with as much root as possible. There were thus two samples of ten from each block ; viz. one hundred from each bed.

The cuttings were brought into the laboratory and each was divided into trunk, branches and roots. The branches and roots were all new growth produced since the time of planting. The branches were further subdivided into primaries (arising direct from the trunk) and secondaries (arising from other branches). The fresh and dry weights of each portion of each cutting were determined ; the mean values are given in Table I. The length of each shoot was recorded also, but these values will not be dealt with in this paper.

The values for roots, trunks and so forth, for the ten cuttings in each sample were summed, and the percentage distribution of weight between the various organs was calculated ; the mean values are given in Table II. The ratios shown in Table III were calculated on the same ten cutting basis. The mean of the two values for each block was used in the analysis of variance ; the five values for each cutting bed gave nine degrees of freedom, one between the two beds and eight that could be allocated to error.

The correlation coefficients shown in Table IV were calculated from the values for the hundred individual cuttings and not from those for the groups of ten.

* The term " trunk " is used in this paper to denote the original piece of stem that was planted as a cutting, together with the thickening subsequently laid down on it by the activity of its cambium.

TABLE I.

DRY WEIGHT OF 100 MYROBOLAN B CUTTINGS GROWN ON TWO DIFFERENT SOILS.

Organ.	Lake soil. gm.	Loam. gm.	Difference. gm.	Coefficient variability.
Primary branches	328·0	216·6	+111·4†	18·6
Secondary branches	264·3	93·0	+171·3*	58·7
Total branches	592·3	309·6	+272·7*	26·9
Trunk	706·3	621·9	+ 84·4	17·7
Total stem	1298·6	931·5	+367·1*	22·2
Root	215·8	180·4	+ 35·4	22·3
Total Dry weight	1514·4	1111·9	+402·5	22·2

* Difference significant ($P<0·05$).

† Difference very significant ($P<0·01$).

Results.

Dry Weights per 100 Cuttings.

The dry weights per 100 cuttings for the Lake (Table I) are consistently higher than those for the Loam, but the difference is mainly in stem weight and particularly in branch weight. The differences in trunk weight and root weight are relatively small and insignificant. These results suggest that the percentage distributions of weight between stem and root and between branch and trunk were different on the two soils, and the stem/root and branch/trunk ratios higher on the Lake soil than on the Loam.

TABLE II.

PERCENTAGE DISTRIBUTION OF DRY WEIGHT BETWEEN VARIOUS ORGANS.

Organ.	Lake soil. %	Loam. %	Difference. %	Coefficient variability.
Primary branches	22·4	18·6	+ 3·8	13·2
Secondary branches	15·4	8·0	+ 7·4*	32·4
Total branches	37·8	26·6	+ 11·2†	9·9
Trunk	48·1	57·2	— 9·1†	7·2
Total stem	85·9	83·8	+ 2·1†	0·9
Root	14·1	16·2	— 2·1†	5·2
Total	100·0	100·0		

* Difference significant ($P<0·05$).

† Difference very significant ($P<0·01$).

Percentage distribution of weight.

Out of every 100 grammes 85·9 were stem on the Lake and 83·8 on the Loam, the difference (2·1), though small, was thoroughly significant owing to low variability (Table II). The relative proportions of branch and trunk were widely different on the two soils, that for branch being higher on the Lake than on the Loam while that for trunk was higher on the Loam than on the Lake. The proportion of secondary stem was significantly higher on the Lake.

Ratios.

The large difference between the two values for the Secondary/Primary ratio (Table III) could not be proved owing to the high variability, but the large difference between the two values of the ratio Branch/Trunk and the small difference between those for the Stem/Root ratio were both highly significant.

TABLE III.

RATIOS BETWEEN PRIMARY AND SECONDARY BRANCHES, TOTAL BRANCHES AND TRUNK, TOTAL STEM AND ROOT.

Organs.	Lake soil.	Loam.	Difference.	Coefficient variability.
Secondary/Primary branches ..	0·831	0·440	+0·391	49·7
Branches/Trunk	0·812	0·477	+0·335†	14·8
Stem/Root	6·138	5·200	+0·938†	7·35

† Difference very significant (P>0·01).

Correlation coefficients.

The coefficients of variability for the percentages, shown in Table II, are consistently lower than the corresponding values of the dry weights shown in Table I. This indicates that the relative proportions of the various parts of the cuttings tend to be fairly constant, irrespective of the actual weight of the individual cuttings. To examine this relation more closely, correlation coefficients were worked out on the basis of the single individual cutting; these are presented in Table IV. The

TABLE IV.

CORRELATION COEFFICIENTS.

Correlation Coefficients between		Lake soil.	Loam.
Stem and Root	r_{SR}	+0·9647	+0·9373
Branch and Trunk	r_{BT}	+0·8903	+0·9075
Branch and Root	r_{BR}	+0·9658	+0·9294
Trunk and Root	r_{TR}	+0·9025	+0·9004
Partial Correlation Coefficients between			
Branch and Trunk	$r_{BT \cdot R}$	+0·1673	+0·4401
Branch and Root	$r_{BR \cdot T}$	+0·8275	+0·6143
Trunk and Root	$r_{TR \cdot B}$	+0·3611	+0·3676

coefficient (r_{SR}) between stem weight and root weight is very high both for the Lake soil and the Loam, being +0·965 in the one and +0·937 in the other. When the cuttings are divided into three portions—branch, trunk and roots, the first order correlation coefficients between each pair of parts (r_{BT}, r_{BR}, and r_{TR}) are still very high, but the second order or partial coefficients ($r_{BT \cdot R}$, $r_{BR \cdot T}$, and $r_{TR \cdot B}$) show that the correlation is closest between Branch and Root weight and is considerably lower where the Trunk is one of the two parts compared. In fact the value for the correlation between branch and trunk, in the case of the Lake cuttings, is lower than the value required for significance.

Discussion.

The small difference in the stem/root ratio between the cuttings on the two soils was thoroughly significant, and was almost certainly a direct effect of differences in soil conditions and not an indirect result arising from differences in total amounts of growth on the two soils.

When a series of stem cuttings is planted on uniform soil, there are no roots and the stem/root ratio at the start is therefore infinitely large for all. As they grow and root, new stem and new root are added and, taking a growing season as a whole, the ratio of new stem to new root tends to be a

constant (Knight, 1934, Vyvyan, 1934), whether the total amount of growth is great or small. At the end of the season the stem is made up partly of old stem and partly of new and the stem/root ratio may be written (old stem + new stem)/(new root). In cuttings that have made little growth, the amounts of new stem and new root are small and the total stem is mainly made up of old stem ; the stem/root ratio is therefore high. In cuttings that have made much growth, the amounts of new stem and new root are large in proportion to the amount of old stem and the value of the stem/root ratio is therefore lower and approaches that of the constant (new stem)/(new root). As the stronger growing cuttings on the Lake soil had a higher and not a lower stem/root ratio than the weaker growing cuttings on the Loam, the difference in the ratio is almost certainly due to an influence of soil conditions on habit.

The amount of branches was much greater on the Lake soil than on the Loam, largely owing to a greater development of secondaries ; part of this difference may have been due to the difference in the total amount of growth on the two soils, since large trees usually tend to have a greater branch/trunk ratio than small trees. The secondaries had a higher moisture content than the primaries and were longer for a given weight, the differences in the total spread of branches on the two soils was therefore considerably greater than the difference in dry weight would indicate.

It is evident, therefore, that soil may influence the growth-habit of a young rooted stock as well as its total size and its rooting performance, and that this must be taken into account when choosing a site for a cutting bed if a particular growth-habit is required.

Summary.

Soil conditions in the cutting bed influence the stem/root ratio and the branchiness of plants grown thereon.

References.

Garner, R. J., and Roach, W. A. (1945). "Comparative susceptibilities of certain horticultural and agricultural plants to trace element deficiencies." *Rep. East Malling Res. Sta. for 1944*, 70-3.

Knight, R. C. (1934). "The influence of winter stem pruning on subsequent stem- and root-development in the apple." *J. Pomol.*, **12**, 1-14.

Vyvyan, M. C. (1934). "The distribution of growth between roots, stems and leaves in a young apple tree and its possible bearing on the problem of stock effect on tree vigour." *Rep. East Malling Res. Sta. for 1933*, 122-31.

BIOCHEMISTRY

MINERAL DEFICIENCIES IN AGRICULTURAL AND HORTICULTURAL CROPS. II.

By W. A. ROACH

Introduction.

The completion of four years' work on mineral deficiencies in agricultural and horticultural crops, carried out by members of the team centred at East Malling, is a convenient time to review the general position, because some idea can now be formed of the complexity of the problems involved and of the rewards likely to be obtained from their solution. The first three years' work has already been summarized (Roach, 1945), and a full report embodying the main results of the 1945 field experiments is in preparation by the workers concerned.

The investigation is one of a number now in progress at various research institutions. The investigations are financed by the Agricultural Research Council and are under the general co-ordination of a Committee set up by the Council. The present report is confined to the work of the East Malling team.

Economic Importance and Wide Distribution of Severe Mineral Deficiency.

There is ample evidence in the literature, most of which has been collected by Willis (1939, 1940*a*, *b*, 1941, 1942, 1943, 1944), for the conclusion that severe trace element deficiencies occur in many parts of the world. In many of the instances recorded there was widespread death of plants and in a number of others cure of the deficiencies was followed by large increases in crop. There is therefore general agreement that such severe deficiencies are of real economic importance throughout the world.

Much of the present work was carried out on freshly ploughed pastures in the marshlands of South Kent, which had the reputation of being some of the richest grazing land in the world and consequently might be expected to be unusually fertile. There were widespread symptoms of manganese deficiency in a number of arable crops. Some of the main results of field experiments on the effect of spraying crops with manganese sulphate solution are given in the following table.

TABLE I.

EFFECT OF SPRAYING WITH MANGANESE SULPHATE SOLUTION ON YIELD OF VARIOUS CROPS AND THEIR INCREASE IN VALUE.

Crop.	Yield per acre.		Increase in		
	Unsprayed.	Sprayed.	Yield.	Value.	Cost.
	cwt.	cwt.	cwt.	£	£
Wheat.. ..	18·5	35·5	17	12	3
Barley ..	22	36·5	14·5	18	2
Peas	9	20	11	26	1
	tons.	tons.	tons.		
Parsnips ..	16·5	21	4·5	80	1·5

It will be seen that, even on this potentially fertile soil, the increases are large in comparison with the yields of the untreated crops and that the financial value of these increases exceeds the cost of the treatment many (from 4 to 50) times over.

Mineral Deficiency in Plants showing no Symptoms.

An even more striking result of the present work was the fact that increases of the order of 10 cwt. of wheat grain per acre were obtained by spraying crops showing no characteristic symptom of deficiency. The deficiency was diagnosed by plant analysis and plant injection and the effect of the spraying was statistically highly significant.

Multiple Trace Element Deficiencies.

In addition to manganese deficiency, plant injection revealed in a number of crops deficienci of iron, zinc, boron, copper and nickel, none of which was indicated by any symptom. Economicall important increases in crop were obtained as a result of spraying each of these elements on eac of the three crops tried, viz. wheat, potatoes and broad beans.

Wide Distribution of Symptomless Deficiencies.

The results of the experiments as a whole leave little doubt that deficiencies of these element (iron, zinc, boron, copper and nickel), as well as that of manganese, may reduce yields to an economic ally important extent without being indicated by any characteristic symptom. It seems reasonabl to conclude that these unnoticed (but economically important) deficiencies are of even wide distribution than the more severe ones that produce symptoms. Two sets of facts suggest that thi tentative conclusion may be of wide application. Firstly, similar symptomless deficiencies have been diagnosed in agricultural crops on the " red soils " of Devon. These soils had a reputation for high fertility, but differ widely in character from those of the Marshlands of Kent. Secondly the same symptomless deficiencies have been diagnosed by the writer and his co-workers in fruit trees and plants over wide areas both in this country and in South Africa and many of the trees were growing on soils of high potential fertility. These facts also suggest that these deficiencies are as widespread and as important in fruit as in agricultural crops.

Universality of Symptomless Major and Trace Element Deficiency

The arable farmer is rarely faced with major element deficiencies that produce symptoms, but he is constantly concerned with symptomless deficiencies. He would state the fact in rather a different way by saying that he is applying artificial manures to produce maximum crops of optimum quality. There is little doubt that both he and the fruitgrower must in future pay the same attention to trace elements as they are accustomed to pay to the major elements. (Indeed, some already do so.) But usually they will not be able to supply the trace elements by ordinary applications to the soil.

Measurement of Effect of Curative Treatment an essential part of Diagnosis.

In the course of the work in the marshlands of South Kent, evidence was obtained that over many thousands of acres there were symptoms of manganese and of practically no other deficiency, and numerous examples were obtained of the crop falling off progressively as the severity of the manganese deficiency symptoms increased. It was tempting to conclude that manganese deficiency was the main cause of the falling off in yield. Actual measurement of the effect on yield of curing the manganese deficiency however, far from supporting this conclusion, suggested that manganese deficiency accounted for only about a quarter of the falling off in yield. This last suggestion was supported by the results of the experiments on the effects of spraying with the other five trace elements, which together had an effect of the order of three times that of the manganese. Field experiments to measure the effect of curative treatments on yield and quality are, therefore, at least at present, an essential part of a complete and accurate diagnosis of mineral deficiency.

Importance of Complete Diagnosis.

A particularly striking example of the importance of complete diagnosis was furnished by a field of potatoes. These showed marked symptoms characteristic of manganese deficiency ; and there was a spectacular improvement in foliage colour following spraying with manganese sulphate, but little or no visible effect of spraying with zinc sulphate. Yet there was no yield increase resulting from the manganese spraying alone. There was, however, a slight increase in yield (about 1 ton per acre) following the zinc spraying. But a combined manganese and zinc spray raised the yield by 4 tons per acre (from 7 to 11 tons per acre). Thus spraying according to diagnosis from the severe leaf symptoms was useless. The detailed results of the experiments suggest that spraying with the correct mixture of all six deficient trace elements would have doubled the crop.

Problems involved in determining correct Dosage.

The results of these curative field experiments give at least indications of the problems involved in determining the correct spray mixture. Obviously a certain minimum concentration is necessary to produce the optimum effect. When only a single element was applied, the concentration could be increased by a considerable amount above this minimum without materially affecting the yield, but after a certain maximum was reached, any further increase in concentration was accompanied by a decrease in yield. This maximum permissible concentration was definitely less than the minimum

concentration that caused damage when sprayed. It is, therefore, not sufficient to choose a concentration just short of that causing damage, but there is a definite range of concentration over which maximum yield is obtained and this range can only be determined by quantitative field experiments, at least for the present.

When a second element was added to the spray the permissible range of concentration of the first was narrowed considerably. Unless the concentration of the first element fell within this narrowed range, little or no beneficial effect was obtained from the second. Whether this narrowed range of concentration is affected by adding further elements has not yet been determined.

In none of the experiments so far carried out was the best effect obtained by spraying once only ; two, three or even four applications were sometimes found necessary. Usually, several sprays of low concentration produced a better effect than one spray of higher concentration. The total amount of element applied in several sprays of low concentration was less than that applied in the single spray. This fact is of more scientific interest than of practical importance (except perhaps in wartime when materials are scarce), because the cost of the trace elements is small in comparison with the cost of application of the spray. On wheat the best effect for a single spray of manganese sulphate was obtained with a 1 per cent. solution, but a better result was obtained from five applications of a $\frac{1}{16}$ per cent. solution.

There were clear indications that the more severe the deficiency the earlier in the plant's life was it necessary to begin spraying.

The results also suggested the desirability of altering the concentration according to the stage of growth of the plant, but not always in the same direction. Thus, in barley, the concentration of the spray should be reduced as the plant develops, but for parsnips the concentration should be increased as the plant develops.

In both wheat and peas it was the later sprays that had the greatest effect on quality ; in wheat on the size of grain and, in peas, on the incidence of Marsh Spot.

Most hopeful lines for further Work.

The problems presented by the diagnosis and cure of mineral deficiency are therefore of considerable complexity even in annual crops. The best hope at present of obtaining even an approximation to optimum results would be for work of the kind just described to be carried out in as many representative localities as possible by research workers, and for their findings to be applied by advisory workers to the whole areas of which the research localities were representative. Simple experiments, devised in co-operation between the research and advisory officers, might well give indications as to how treatment should be modified to suit local circumstances. But crops such as tree fruits present far greater difficulties both in the basic research work and in the degree of local variation. The crop increases already obtained provide ample justification for a considerable development along these empirical lines. Such work besides yielding results of considerable immediate economic value should also lead to generalizations that would simplify the whole problem.

Curative Methods.

So far this report has mentioned no curative method other than spraying, but there are a number of alternative methods and choice of method must depend on the circumstances of each case. Simple *application to the soil*, when effective, has the strong recommendation of simplicity and cheapness, and farmers are already used to it for the applications of major elements in the form of artificial manures. This method is sometimes effective for trace elements ; and sowing the nutrient substance down the same spout as the seed, so that it is " placed " near the seed, should tend to be more efficient than broadcasting or sowing with a drill in a different operation from seed sowing. It is sufficiently effective for manganese to justify the incorporation of manganese sulphate into all artificial manures supplied to certain manganese deficient areas of the Fens. But this method was found practically ineffective on the Marshlands of South Kent and was therefore discarded in favour of *spraying*. Certain of the farmers there are spraying arable crops the necessary number of times, because they have been convinced by watching this experimental work that the crop increases and the improvement in quality, notably in peas, justify the trouble and expense. A third method, *soaking the seed* grain in a solution containing the element has given remarkable results in the course of this work. Large increases in yield resulted from this type of application of phosphorus and probably potassium ; and in a preliminary experiment, in which oats did not reach maturity, manganese had an encouraging effect in that it increased growth and prevented the formation of the lesions characteristic of manganese deficiency. The nutrient substance was held in the outer layers of the seed ; and the essence of this treatment appeared to be to hold the nutrient in some

absorbent material, in which it would be protected from the "fixing" action of the soil and h close to the seed, where it would be easily reached by the developing rootlets. If this be so, equa good, or even better, results might be obtained by supplying the nutrient substance in some absorbe material other than the seed coat. This could be soaked and dried much more simply and econom ally than the seed without incurring any risk of damaging the seed. If the material were in suitable state of division, it could be sown with the grain and the nutrient would be reached by t rootlets nearly as quickly and easily as when absorbed in the seed coat. This fourth method shou combine the advantage of placement with that of some degree of protection from soil fixation. fifth method, applicable only to large plants such as fruit trees, is provided by *plant injection*. Th also is being applied on a commercial scale.

Three of the above five methods are already in commercial use and the other two methods see likely to be applicable also on a commercial scale. There is therefore no dearth of curative metho To get the best results from any of them, quantitative field experiments would be necessary to dete mine the correct dosage. The difficulties and complexities inherent in such experiments have alread been indicated, but the curative methods remain relatively simple. Even if a number of substanc have to be included in the curative solution, dressing or injection tablet, their incorporatio complicates the operation but little and does not affect the mode of application at all.

Empirical Nature of Present Work.

It will be noted that the methods employed in this work have been empirical. *Diagnosis b analysis* has been based on comparisons of less satisfactory with more satisfactory plants. Eve though a certain minimum content of each element has been found to be associated with satisfactor performance, there is no theoretical basis for the determination of these minimum contents. high content of calcium has been found to make any deduction drawn from a normal or even hig content of iron unreliable ; the same is true for boron, zinc and probably certain other trac elements, and probably also for phosphorus and silicon. There is some hope that selectiv extraction methods devised along empirical lines may lead to improvements. But so far no seriou attempt has been made to relate the amounts of any of these elements and their state of combinatio to their ability to serve their functions in the plant. *Diagnosis by plant injection* is based on a increase in size or an "improvement" in colour or appearance following the injection of a particula nutrient. The diagnosis rests on no more secure foundation than that such changes in size, colou or appearance in the leaf are commonly accompanied by an improvement in performance of the plant But it is well known that the increased growth or depth of green colour of foliage resulting from a application of nitrogen is by no means always accompanied by an improvement in performance So far, no such result has been obtained for any other element. (The nearest approach is the result of an artificial market requirement. A slight degree of iron deficiency gives certain varieties of apples a yellow instead of a green ground colour. Although the value per bushel is enhanced, the cropping is impaired.) Even when the injection prevents the formation of symptoms looked upon as characteristic of a deficiency, the diagnosis is still not certain because no direct causal connection has yet been proved between any symptom and a mineral deficiency. For example, all stages in the formation of marginal scorch (usually a sign of potassium deficiency) may be produced at will, at least in certain varieties of apples, by the injection of one of a number of salts that include potassium nitrate (Roach 1938, p. 62). And, finally, the assessment of the effects of curative treatments by field experiments has been carried out along purely empirical lines.

Need for Academic Work.

The results achieved by these empirical methods justify work along physiological and biochemical lines such as those being undertaken by other workers, the aims of which are to determine the effects of individual nutrients on the various physiological functions such as photosynthesis and translocation, and to determine the enzyme systems into which the nutrient elements enter. Such work should not only put diagnostic and curative methods on a more secure theoretical basis, but might also simplify some of the present empirical procedures.

Mutual Relations of Academic and Field Work.

Although there is good hope that such theoretical work would simplify field work, there is none that it would replace it. The main reason for this is that the relation between the plant and its source of mineral nutrients, the soil, is a highly dynamic one : the crop plant is only one of many competitors (weeds, algae, fungi, bacteria, protozoa and numerous kinds of animal life) for these nutrients, and

the solid soil particles themselves lock the nutrients up in forms of a wide range of availability, while the degree to which these are released again varies with moisture content and other factors. This highly dynamic equilibrium can only be studied sufficiently for practical purposes in the field. Moreover the equilibrium varies considerably during the season, both from the causes already mentioned and because the needs of the crop plant vary with age. Work in the field and in the laboratory must, therefore, remain complementary and mutually helpful.

The Problem for Fruit.

Facts already mentioned in this Report suggest that severe mineral deficiency accompanied by characteristic symptoms is of serious economic importance in fruit. But when leaf analysis and leaf injection are applied to plants so affected, other deficiencies are often indicated in addition to those revealed by the symptoms alone. Further, both here and in South Africa, the same methods have suggested deficiencies in a large proportion of symptomless plants taken at random.

The general indications of these methods in regard to fruit, therefore, are exactly the same as for agricultural crops. It cannot be assumed for fruit, any more than for agricultural crops, that an "improvement" in colour or appearance of foliage will necessarily be followed by an increased crop or better quality. But the large increases in crop and improvement in quality obtained as a result of treatment of these symptomless deficiencies in agricultural plants do suggest that the similar indications in fruit trees are well worth following up. Facts have already been given in support of the conclusion that quantitative estimation of the effects of curative treatment on yield and quality of crop is an essential part of diagnosis. These facts were derived from work on agricultural crops, but there is every reason to think that they apply equally to fruit. And there is no reason to think that any of the difficulties encountered in determining the best curative treatments for the former will not be equally great for the latter. In addition, the highly artificial methods of culture of perennial fruit trees introduce many complicating factors ; and quality is more important and complex in fruit than in agricultural crops.

The problem, therefore, is even more complex in fruit than in annual crops and the number of experimental units must be at least as great, if equally rapid progress is to be made. The smallest unit likely to be of use in such work for apple trees is a branch of a spur-pruned tree. An experiment consisting of many hundreds, probably thousands, of such branches is not to be undertaken lightly. Either experiments of this magnitude must be initiated, and repeated over a number of years to include the effects of frost and biennial bearing, or a much slower rate of progress must be expected for the present. The greatest hope of rapid progress in fruit over a period of years is for the general principles to be worked out on annual crops, in conjunction with physiological and biochemical investigations such as those mentioned earlier. Such work should lead to relatively simple general principles that could then be tested on fruit. But in the mean time numerous suggestive results already obtained on fruit are well worth following up.

Summary.

The paper summarizes the main conclusions drawn from four years' work at East Malling and carried out as part of a cooperative effort by means of a grant from the Agricultural Research Council. Mineral deficiencies were diagnosed by plant analysis, plant injection and the estimation of the effect of curative treatment on yield and quality by quantitative field experiments. The work was concerned with deficiencies of phosphorus, potassium, calcium, magnesium, iron, manganese, zinc, boron, copper and nickel and with fruit trees, oats, wheat, barley, peas, carrots, parsnips and potatoes. Large increases in yield were obtained, both when the deficiencies were suggested by symptoms and when no symptoms were apparent. The importance of complete diagnosis was demonstrated by an experiment in which treatment according to diagnosis by symptoms alone was ineffective, whereas when all the six elements, found by plant injection to be deficient, were supplied the crop was doubled. Some of the problems involved in determining dosage were dealt with and were found to be very complex. Suggestions are made as to the lines along which future work might most advantageously be directed.

References.

Roach, W. A. (1938). "Plant Injection for diagnostic and curative purposes." *Imp. Bur. Hort. and Plant. Crops, Tech. Commun.* 10.

——— (1939). "Plant Injection as a physiological method." *Ann. Bot. N.S.*, 3, 155-226.

——— (1945). "Mineral Deficiencies in Agricultural and Horticultural crops." *Rep. E. Malling Res. Sta. for 1944*, 43-60.

WILLIS, L. G. (1939). Bibliography of references to the literature on the minor elements and relation to plant and animal nutrition. Third Edition. *Chilean Nitrate Education Bu... Inc., 120 Broadway, New York, U.S.A.*
—— – (1940*a*). Botanical Index to above.
—— – (1940*b*). First supplement to above.
——— (1941). Second supplement to above.
——— (1942). Third supplement to above.
—— – (1943). Fourth supplement to above.
——— (1944). Fifth supplement to above.

PHYSIOLOGICAL EFFECTS OF TRACE ELEMENTS

By B. D. BOLAS

Dr. Roach's leaf injection methods for the diagnosis of mineral deficiencies have opened a new field for physiological work on plant nutrition and preliminary experiments during 1945 have given most promising results.

Roach's work indicated that potato plants (Majestic) grown on the dry lake bed at Bradbourne are deficient in manganese. This was shown by the fact that, at certain times of the year and at certain stages of leaf development, the injection of a dilute aqueous solution (·025 per cent.) of manganese sulphate is followed by increased greenness and a more healthy appearance of the injected leaves. The finding was confirmed by spraying the young plants with a solution containing manganese which resulted in an increased yield of potatoes.

These facts presented an opportunity for a study of the effect of one of the trace elements (manganese) on various physiological processes, namely assimilation, translocation and growth, and a scheme of work was evolved.

The Sachs, Ganong and Thoday methods of measuring assimilation were all found unsuitable for one or other reasons and the Bolas " paired-plant " method was inapplicable. It was therefore necessary to evolve a field method which would give significant results with relatively small samples. Such a method has now been brought to a practicable stage and will be described elsewhere. It was used in the autumn of 1945 on the manganese deficient potatoes grown and injected with manganese under Roach's supervision, and has given some very promising indications, namely—that in autumn when the leaves are near senescence :—

(*a*) The injection of a dilute aqueous solution of manganese sulphate was followed after an interval of about ten days by a 20 per cent. increase in assimilation rate ($P = \cdot 001$), which lasted about a week and was not necessarily associated with any visible change in the injected leaves.

(*b*) There was no indication of any effect of the injection on translocation rate.

(*c*) There was no evidence of movement of manganese to the uninjected leaves.

While these results must be regarded as subject to confirmation they appear to open up a new approach to deficiency problems.

Acknowledgement.

The author wishes to express his appreciation of Dr. Roach's help and collaboration which has made the work possible.

Summary.

The injection of an aqueous solution of manganese sulphate into lateral leaflets of potatoes suffering from manganese deficiency resulted in an increased assimilation rate in comparison with corresponding leaflets on the other side of the leaf. This has opened up a new line of investigation of the physiological function of trace elements on plants.

ENTOMOLOGY

NOTES ON SOME INTERESTING INSECTS OBSERVED IN 1945

By A. M. MASSEE

1. Ground Beetle (*Laemostenus terricola* L.).

It is interesting to record the ground beetle, *Laemostenus terricola* L. eating apples kept i storage in the cellars of houses in the Aylesford district of Kent. The damaged fruits were first in October, when dessert apples of the variety Cox's Orange Pippin and Sunset were seen to large pieces eaten out of the flesh. It is significant that the beetles did not damage culinary a in the same stores. The beetles were actually noted feeding on the fruits, and later when some beetles were kept in captivity they fed readily upon the flesh of the apples, but only at This kind of injury to stored apples may prove very troublesome should the beetles become plen since soft brown rots set in where the beetles have been feeding, and the fruits readily decay.

Laemostenus terricola L. is locally common in the neighbourhood where it occurs in outhe sand pits and in the wooded areas under leaves and large flat stones. This beetle is $\frac{1}{2}$ to $\frac{3}{4}$ inch blue black with pitchy black long legs. It becomes very active when disturbed and moves a only at night.

2. Little Longicorn (*Tetrops praeusta* L.).

This pretty little buff-coloured Longhorn beetle with head, thorax and underside black is frequ seen resting on apple and pear foliage in April and May.

A number of adults were noted emerging by way of a small, round cylindrical hole made in tips of spurs of old pear trees at East Malling. Most of the beetles emerged during the latter of April, and at once began to feed on the foliage. They feed only on the epidermis and cause little harm to the trees.

It is likely that this beetle is found only in old and neglected orchards, since it has not b recorded in well-cared for commercial plantations.

It is widely distributed in the southern half of England, and may be found commonly on flo heads in May, and by beating dead twigs in hedgerows, etc.

3. Apple Twig Cutter (*Rhynchites coeruleus* Dg.).

Correspondence and reports in the press indicate that the Apple Twig Cutter is widespr and is causing considerable harm, particularly to young fruit trees, by cutting off the new grow in May and June. Much damage was noted to apple, pear, plum, cherry, peach and nectarine in Maidstone district, while at Sherborne Hill, Basingstoke, Hants, severe injury was reported to lau bushes and whole heads of wisteria plants were cut off.

According to Theobald and other workers this insect is stated to hibernate in the larval st in the soil. This is not correct. The Apple Twig Cutter overwinters in the adult state in dead leav under loose bark and in sacking bands from November until the spring. Large numbers have be collected in December and January from sack bands placed round apple stems at Kirdford, W Sussex; East Malling, Kent, and at Wickham Bishops, Essex.

4. Apple Fruit Rhynchites (*Rhynchites aequatus* L.).

Although the Apple Fruit Rhynchites has been referred to five times previously in these not some recent observations are well worth recording. Attacks by the adults to apple fruitlets ha been general in Kent, and in many instances the damage caused by them must be regarded as seriou At Graveney, East Kent, a very bad infestation was noted, the worst attacked varieties being Lan Prince Albert and Worcester Pearmain. Charles Ross and Beauty of Bath were attacked to a less degree.

The adults were plentiful on the trees in the East Malling district during the blossom period an soon after petal fall, started puncturing the apple fruitlets. Many of the punctures were fou to contain eggs, in fact, eggs were found much more plentifully in the fruitlets than in previo years. Two weeks after petal fall, numbers of weevil larvae were found in the fruitlets, and detail

bservations showed these were the larvae of the Apple Fruit Rhynchites. Odd larvae have been oted in the fruits as far back as 1936, but this is the first occasion they have been found feeding on he apple flesh in considerable numbers.

It is obvious that this insect is now established on cultivated fruits, and it is able to complete ts transformations within the flesh of the fruits. Thus, before many years have elapsed, it may vell be regarded as an important pest together with the Codling Moth, the Apple Sawfly and the Apple Fruit Miner.

The Apple Fruit Rhynchites was recorded first in 1928, when it was found in a commercial orchard of Fearn's Pippin at Swanley, Kent. Thus its progress in establishing itself on fruit has been remarkable. This happens to be one of the very few fruit insects found commonly today that the late Professor F. V. Theobald did not mention in his numerous writings.

5. Strawberry Rhynchites (*Rhynchites germanicus* Hb.).

Reference to the work entitled " Insect Pests of Fruits and Hops ", and to Theobald's " Insect Pests of Fruit", shows that two species of *Rhynchites* were formerly recognized as infesting the strawberry. They were the Small Rhynchites (*Rhynchites germanicus* Hb.) and a larger species with the scientific name of *Rhynchites minutus* Herbst. (—*aeneovirens* Mm.).

Observations made yearly since 1937 convince the writer that only one species of *Rhynchites* is associated with strawberry, namely *Rhynchites germanicus* Hb., and the popular name of Strawberry Rhynchites is proposed for the species.

Rhynchites minutus Herbst. (—*aeneovirens*) is associated with oak, mountain ash, etc., and occurs commonly in woodland clearings in April and May. Specimens collected from Oaken Wood, East Malling, were transferred to wild and cultivated strawberry, but were not observed feeding on the plants.

In common with the two apple species of *Rhynchites* referred to above, the strawberry species has been unduly abundant in 1945. Reports of its attacks upon cultivated strawberry have been received from East Malling, Maidstone, Mereworth, and King's Wood, near Sutton Valence, Kent ; Danbury and areas around Colchester in Essex ; also from Leicestershire. The adults were prevalent in April, a month earlier than in some seasons, cutting off the petioles of the leaves and twig-cutting the blossom stalks over large acreages of strawberry beds.

The Strawberry Rhynchites is by no means confined to the strawberry, since it is very partial to cultivated Rubi, being particularly attached to cultivated blackberries, and to a lesser degree loganberries.

During the first week of May, the writer's attention was drawn to a 10 acre field of blackberries growing at Yalding, Kent. All the new laterals had been damaged—many completely destroyed—by this weevil, and the damage presented a very sorry sight. At first the grower thought that the damage was due to a recent frost, but a closer inspection revealed the presence of tens of thousands of the little blue-black weevils with their long snouts. The injury had become so serious that the grower decided to dust without delay. Two dusts were used, a 5 per cent. D.D.T. and a 5 per cent. benzene hexachloride dust. The dusts were applied with a hop dusting machine at the rate of 40 lb. per acre. Both proved very efficient and no further damage was noted. Two acres of loganberries growing adjacent to the blackberries were also attacked, but the damage was far less severe. The treatments referred to above were applied and proved adequate.

As mentioned already, the Apple Fruit Rhynchites, the Apple Twig Cutter and the Strawberry Rhynchites have been increasing steadily for several years, and each one of them must be regarded as an important pest associated with top and soft fruits. It is realized that injurious insects have their " peak " seasons, but these three species of *Rhynchites* have been prevalent on fruit for a number of years consecutively, and not merely in a season particularly suitable for their development. It is fortunate that the two new insecticides, D.D.T. and benzene hexachloride, control these insects adequately, since it only remains for the Entomologist to advise on the correct timing of the applications, and the minimum amount required to kill them.

6. Fruit Bark Beetle (*Scolytus rugulosus* Rz.).

The Fruit Bark Beetle attacks many kinds of trees, but, of the cultivated fruits, it is usually associated with damson and plum. It is therefore of interest to record it infesting pear in two widely separated parts of Kent. It was found infesting the spurs of an unknown variety of pear in a garden at Sidcup, Kent. The second outbreak was noted at the Research Station, when the spurs of young wood of some weak trees of the variety Conference were found to be infested. The adults started to emerge on 14th April, and continued for several weeks.

The grub stage of this species is readily devoured by predaceous birds, and the very persistent

way in which they " work " the galleries to get at the grubs, often gives the first indication of the presence of the bark beetles.

7. Shot Hole Borer (*Anisandrus dispar* F.).

The association between the Shot Hole Borer and the condition of the fruit tree is not understood, but one invariably finds trees growing in waterlogged or undrained land suffering from attacks of this and other wood-boring beetles. Such was the case at Danbury, Essex, where two Cox trees growing in waterlogged soil, and obviously unhealthy, were riddled by the borings of the beetle. These trees died and were removed, while many others were found to be infested in the stem and main branches.

At Tenterden, Kent, a number of sweet cherries proved to be infested by this species. The trees were unhealthy and affected by Bacterial Canker. The adult beetles were emerging from their galleries in May, which is considered somewhat late in view of the very early season.

8. Flat-celled Shot Borer (*Xyleborus saxeseni* Ratz.).

This wood-boring beetle has been referred to only once before in the Notes, in 1935, when it was mentioned briefly on apple in West Sussex.

Large colonies were found infesting some 7-year-old sweet cherry trees at Tenterden. This insect always occurred in association with the Shot Hole Borer (*Anisandrus dispar* F.) and in common with allied species seemed to prefer the unhealthy trees.

This species can be distinguished from the Shot Hole Borer in the field by the form of galleries it makes in the stems. The brood-tunnels are narrow and flat, compared with the cylindrical burrows made by the Shot Hole Beetle. It bores into the sapwood and the tunnel terminates in a large chamber in which all stages of the insect live.

This is an interesting insect which would well repay more detailed study.

9. Clay Coloured Weevil (*Otiorrhynchus singularis* L.).

Although the Clay Coloured Weevil is not readily detected in the field, the injury it causes to various fruit trees and soft fruits is familiar to many growers. The injury caused by this insect to raspberry spawn and young seedlings in the spring months, however, may not be recognized, unless the symptoms are noted and the adult weevil is seen at work. It is not easy to find the weevil actually feeding, since it becomes active only after nightfall.

The damage may be very varied. On fruiting canes it is usually confined to the blossoms, blossom buds and the foliage, but the weevils gnaw the rind of the tender shoots and eat out the tips of the seedlings, frequently causing branching of the canes, which grow in a stunted manner and are of little further use. Most serious damage occurs during the latter part of April and May, but the weevils continue to feed for several months, the injury becoming less noticeable later on owing to the plentiful supply of new canes. Such injury occurred on several of the experimental raspberry plots at the Research Station, while reports were also received from growers in various parts of Kent.

This weevil seems to prefer infesting raspberries growing on light soil, but plants growing on chalk, clay and heavy soils are also subject to attack.

The grub stage of the weevil is also harmful, since it attacks the fibrous roots of the raspberry. Thus the attack, in one form or another, may go on all the year round.

10. Cockchafer (*Melolontha melonontha* L.).

From time to time the adults of the Cockchafer or Maybugs become mischievous by feeding on apple fruitlets and destroying them. Such damage was noted in Kiln Field, East Malling, during the third week of May. The attack was not confined to any one variety, the beetles flying short distances, indiscriminately nibbling at a fruitlet, and then moving on and feeding on another. The feeding persisted for several days, and eventually the chafers flew away and were not noticed again.

Every few years similar attacks are reported from various parts of Kent, and it would be interesting to know why these chafer beetles infest our fruit crops so intermittently, since they are abundant in Kent every year.

11. Leaf Weevil (*Polydrosus cervinus* L.).

The very familiar leaf-eating weevils which infest top and soft fruits in May and June belong to the genus *Phyllobius* ; thus it is very interesting to record a species of *Polydrosus*, a closely allied genus, feeding on the foliage of apple, pear, plum, cherry, nut and hawthorn at East Malling during

the last week of May. The adults were feeding on the leaves, but the damage they caused was negligible compared with that caused by several species in the genus *Phyllobius*.

In addition, a single specimen of *Polydrosus sericeus* Sl. was found feeding on a Waterloo cherry leaf in the writer's garden at East Malling. This species also occurs on strawberry, but it is more frequently associated with oak and other trees growing in woodland districts.

12. Vine Weevil (*Otiorrhynchus sulcatus* F.).

This weevil is a pest well known to the horticulturist, because it causes serious damage to vine and other plants growing under glass. During recent years it has established itself in the experimental greenhouses at the Research Station, and the adjacent bedding grounds. So far its attacks have been confined to strawberries and hops growing in pots, and, on these plants, both the adults and the grubs of the weevil have been causing damage. Curiously enough, raspberries growing near these affected plants have not been attacked.

A number of the weevils were collected and confined on strawberry plants growing in pots. The plants and the weevils were dusted with D.D.T., but this insecticide had little or no effect upon the adults of this insect.

13. The Spring Usher (*Erannis leucophaearis* Schiff.).

The Spring Usher is one of the fourteen British species with wingless females. It is a locally common species in most English counties, and the male is on the wing from January to March. In Kent, it is generally found in February. The normal host of this species is oak, but it occurs sparingly throughout the fruit areas of Kent, and may be found each season resting on apple tree trunks in February. The male is more readily detectable than the wingless female, unless a diligent search is made for the latter. During 1945, the males were common during the third week of February in the East Malling district, and several were received for determination.

The caterpillar, a typical looper, is of a green hue with yellowish lines on the back, and brownish markings on the side. It occurs on apple in April and May, and adds to the destruction caused by the larvae of the Winter Moth group generally.

The male moth has forewings, yellow-whitish marked with fuscus and sprinkled black. There are two longitudinal curved lines. The hind wings are pale. Some specimens have darker markings, while others are black. The female is greyish-brown, the small traces of wings are brown and whitish.

14. Feathered Thorn (*Colotois pennaria* L.).

Feathered Thorn cannot be regarded as an important fruit insect; it is enquired about by fruitgrowers year after year, because it deposits its eggs in an oblong batch of 100 to 200 eggs on the twigs of apple and other fruit trees. These egg batches are noticed by the pruners while at their work, hence the enquiries.

The moth is on the wing in October and November, but it is rarely seen by the grower. The egg is olive green with a ring of pale spots at its apex. The looper caterpillar, which hatches in April, is slate-grey with a purplish tinge, with a row of yellow spots along each side, and is marked with yellowish diamonds on the back. The projections at the hind end have reddish tips.

It is a very common species, especially in woodland districts, and it is plentiful in the Maidstone district. Enquiries from Worcestershire indicate that it is common there also.

15. V Moth (*Itame wauaria* L.).

Although gooseberry is the recognized host plant of the caterpillar of the V Moth, this insect does not seem to cause any serious harm to the plant. At least it is not often noted by the grower or, more probably, has been mistaken for the larva of the Gooseberry Sawfly. In 1945, several enquiries were made about this insect, and it also occurred on some gooseberry-currant crosses growing in the round bed at the Research Station.

The looper caterpillar is green, green-grey or lead-grey with four waved yellowish white lines along the back, and a yellow line along the sides, with darker spots. It feeds on the foliage in May and June.

The chrysalis is formed in the soil, and the moth is on the wing in July. The wing expanse is an inch and a quarter. The forewings are grey, sometimes tinged with purple. Characteristic dark markings including a V-shaped mark (hence its name) are very prominent. The hind wings are grey with a central spot.

The larva of the V Moth is very interesting to watch in the field, because it lives with and mimicks the larva of the Gooseberry Sawfly, which it closely resembles. The two, however, can be separated at once by the number of false legs.

On parts of the Continent, particularly Germany, this insect is regarded as a pest, so its presence on Ribes in this country must not be lost sight of.

16. Codling Moth (*Cydia pomonella* L.).

The Codling Moth has been referred to in these notes on eight previous occasions and might well be mentioned every year, since the life-cycle and habits have not been studied adequately in England.

Owing to the early season, the moths emerged sooner than usual, and adults were seen flying in the apple orchards at East Malling during the last week of April. Eggs were noted on the fruitlets during the first week of June and egg-laying continued until the end of June.

There was evidence of a partial second generation in the Maidstone district. Fully fed larvae and pupae were noted in some weevil " sack bands " during the latter part of August, while eggs were still being laid on the fruits as late as 18th August. From time to time a partial second generation occurs in this country, but the climate is not suited to the production of several generations, as is usual in some States of the United States of America.

Most of the apple orchards at the Research Station were sprayed with lead arsenate, at the rate of 2 lb. powder to 100 gallons water, during the second week of June. This treatment gave adequate control of the pest, which was prevalent on neighbouring farms where shortage of labour prevented the spraying being done. Codling Moth was also very troublesome in Essex, but spraying with lead at the correct time proved successful there also.

17. Moths of the Winter Moth Group.

During the weekend of 7th to 9th December, which was preceded by a very cold, frosty spell of weather, the Winter Moth, Mottled Amber and other species, which emerge at this period of the year, proved to be abnormally abundant in the East Malling district, and indeed it is probable that the infestation was greater than for many years past. These moths proved to be abnormally common throughout Kent and the fruit belts of Essex.

The writer's attention was called to some grease bands on established cherry trees in a grass orchard near East Malling, on which up to one thousand wingless females per band were caught. It was not possible to count accurately the males and females on each band, because the bands had been " worked " by birds earlier that morning. The trees examined were very large, but even so the catch was prodigious. An abnormal catch was noted on most of the trees throughout the orchard. Neighbouring apple orchards and plum plantations were also very heavily populated by these moths. Moths were still noted on the wing in the district during the evening of 19th December, but after that date very few males were noted after dusk. The wingless females were still ascending the tree trunks during the third week of December.

It is curious that such a heavy infestation should occur this autumn, since the caterpillar population in the orchards in question last spring was not greater than usual. Every moth noted this autumn must have been in the caterpillar state last April and May, but how such vast numbers of moths appeared in the orchards without the trees being completely defoliated earlier in the season remains a mystery.

It is unlikely that the wingless females are carried by the males to the orchards from neighbouring wooded areas, since in the course of many years' observations this mode of migration has been noted only three times.

The fact remains that in spite of the modern methods of pest control, the grease-band is by no means redundant, especially on very large trees where the spraying for various reasons is too frequently inadequate.

18. Crab Leaf Miner (*Nepticula malella* Sta.).

The Crab Leaf Miner, which was reported from the Bedford district in the autumn of 1944, also turns up occasionally on apple in the Malling district. It is a typical leaf miner, and the gallery made by the minute caterpillar is very characteristic. It starts as a small, thin tunnel, which gradually enlarges, and terminates in a large chamber-like area. It is green at first, but later on becomes yellowish-green. The foliage of Cox's Orange Pippin is very subject to attack, and in some years it occurs among the Malling rootstocks.

Frequently five or six leaf miners may be at work on one leaf, but the damage is not regarded as serious.

There are two broods in the year. The first appears in late May and June, the second early in August.

The moth is minute and is rarely seen. It has a wing expanse of 4-5 mm. The forewings are black with a longitudinal white band on each. The hind wings are grey with long fringes.

The larva is pale amber to yellowish with a pale central line. The head is brown and the body slightly hairy.

The natural host plant of this insect is the wild crab apple, thus its presence on cultivated varieties and stocks is not surprising.

19. Plum Sawfly (*Hoplocampa flava* L.).

Since the Plum Sawfly became a major pest of plum in the south-east of England in 1930, its importance in the plum plantations in the Maidstone district has varied from year to year. Some seasons it is regarded as a serious pest, particularly on the variety Czar, while in others it is not common enough to bother about. It proved to be generally scarce in many parts of Kent in 1945, and one orchard of Czar plums at East Malling, which is usually very heavily infested, was practically free from attack. Prolonged searches for the adult sawflies during the flowering period produced only two specimens, which were caught on 30th March.

It is curious that this insect should fluctuate in numbers from season to season, and at present there does not appear to be an explanation.

The Apple Sawfly, a closely allied insect, was by no means uncommon in the same districts, and many growers applied one or more applications of nicotine after petal-fall to help protect their apple crops.

20. Lacewing Fly (*Coniopteryx tineiformis* Curtis).

This beneficial insect proves to be very plentiful in the apple orchards, at certain periods of the year, in many parts of Essex. It has been noted at Writtle, Danbury, Great Braxted, Wickham Bishops, Chelmsford, Colchester and at Brentwood. So far it has not been seen in Kentish orchards.

It would appear to ascend the trunks of the apple trees in the latter part of August in the form of larva, and then proceed to spin its cocoon, and attach it to the tree trunk. The cocoon is a small, flat, circular structure of white silk, about an $\frac{1}{8}$ inch in diameter. The winter is spent in prepupal stage within the cocoon. Frequently several hundred cocoons, which are very conspicuous, occur on a single tree, and naturally growers enquire what they are doing there, and if they are likely to cause any harm. Fortunately the cocoons of this beneficial insect seem to be impervious to winter washes, since the lacewing emerges from cocoons sprayed with a tar oil and a petroleum spray.

The adult lacewing fly which has a wing expanse of $\frac{1}{4}$ inch, emerges from the cocoon in May or June. There are two generations in one year, the second appearing in August. The small larva, which is predaceous, has been observed feeding upon all stages of the Fruit Tree Red Spider, and this fact doubtless accounts for its presence on apple in Essex, where the mite is plentiful.

It has a wide distribution in England, being recorded from twenty-four counties. It is more usually associated with Scots pine, larch, alder, birch, elm, oak, beech, sallow and hawthorn according to Dr. F. J. Killington, an authority on the group.

21. Strawberry Tarsonemid Mite (*Tarsonemus pallidus* Bks.).

It was stated in these notes two years ago that the Strawberry Tarsonemid Mite was steadily increasing in commercial strawberry fields in many parts of the country and that it was likely to be a serious pest during the first dry summer to follow. Well, 1945 proved to be a dry summer, if not a very warm one, and as predicted the mite has become a serious pest in many parts of Kent, Hampshire, Worcestershire, and Cambridgeshire.

Growers are therefore advised to procure runners for planting out new beds from a source where the mite is not prevalent. If the presence of mite is suspected, then it is essential to carry out the warm water treatment prior to planting. There is still no method of obtaining adequate control of the mite under field conditions. The two new insecticides D.D.T. and benzene hexachloride have no toxic effect upon this troublesome pest.

Summary.

Notes and observations are given on twenty-one insect pests and mites noted in 1945, several of them being noted for the first time.

HOPS

PROPAGATION TRIALS WITH HOPS

II. PRELIMINARY TRIALS IN PROPAGATION BY SOFT-WOOD CUTTINGS*

By F. H. BEARD and DOROTHY J. WILSON

Introduction.

At the present time there is urgent need for the rapid propagation of hops by intensive methods from small nuclei. In the case of existing commercial varieties it is essential, if they are to be rejuvenated, that propagation should be carried out only in special propagation gardens of disease free material. Only very small plots of the new varieties showing resistance to Verticillium Wilt are in existence and, with the ordinary methods of propagation, many years must pass before they are available in sufficient quantity to replace the Fuggle on infected land.

There are two possible methods of intensive propagation, by layers and by soft-wood cuttings. Layering is only the production by artificial means of runners which the hop produces readily under natural conditions. Layering has been carried out in the past by a few growers when building up a special stock. It presents no special difficulties, though improvements in technique are no doubt possible.

Propagation by means of soft-wood cuttings is an entirely new departure and was first tried by Bailey (1939). He found that certain of the new varieties raised by Professor Salmon could be propagated from soft-wood cuttings made from young surplus shoots (" asparagus " stage) from the hills in the spring and laterals taken from the lower portion of the bine (which are normally removed in commercial practice) later in the season. The young basal shoots were found to root without the aid of root-initiating substances, though their use hastened rooting.

Basal shoots which had their lower portions blanched by a slight earthing of the hills in the early spring rooted more readily than shoots from unearthed hills. Lateral shoots were found to root only with the aid of a growth substance. Basal cuttings produced sets fit for planting out, but sets from laterals needed bedding out in the nursery for a season.

Bailey's method was to plant five cuttings in a 48 (4½ in.) pot placed in a small frame or under a bell jar in cool greenhouse. When rooted, the cuttings were potted up singly and finally transplanted.

Professor Salmon kindly supplied the following particulars of the methods used at Wye subsequent to Bailey's work. " Mr. Arthur Dodd, who has been attending to the propagation of the new varieties of hops at Wye College for many years, has successfully employed the following method of striking ' soft-wood ' cuttings : As soon as the first shoots are showing in the spring, the ' hill ' is covered with from 1 to 1½ in. soil. When the shoots have emerged and made sufficient growth (about 1 ft.), they are carefully pulled out from the base, when it will be found that the majority show a firm white base about 2½ in. in length. The shoots are then planted inside a cold glasshouse in a frame containing a mixture of peat and sand (1 part sand to 4 parts peat) which has been thoroughly wetted and consolidated by treading. The shoots are planted 3 in. deep, and no ' rooting solution ' is used ; the lights are kept on from 10-14 days (according to weather), and the plants are syringed overhead, once a day, if the weather is cool, and as many as three times a day in warm sunny weather. The frames are shaded by sacking when necessary. Ventilation is given gradually at the end of 14 days, at first by 1 in. blocks placed under the lights ; the latter are gradually lifted higher according to weather conditions until they are removed after a month's time. Approximately 60 per cent. of the shoots will be found to have rooted. These rooted cuttings, if removed in June with a well-wetted ball of peat round their roots, and transferred to the open ground nursery, will grow on into the ' rooted sets ' of commerce, and in a large number of cases will attain to the standard of grade 1.

" The following varieties were propagated by the above method in 1946 : Bullion Hop (Q43), College Cluster (N15 *bis*), Malling Midseason (BB28), 170a and V94.

" A modification of the above method is used when it is desired to propagate from a single plant by means of ' soft-wood ' cuttings. Shoots are obtained in spring in the manner described above and 5 to 6 are inserted in a 32 (6 inch) pot containing a mixture of soil and sand (1 part sand, 3 parts ordinary potting soil). The shoots are syringed and the pot is then covered by a tall bell-jar and stood on the ground which is kept moist in a shaded part of the cold glasshouse. After 14 days the bell-jar is

* These investigations were assisted by a special grant from the Agricultural Research Council.

removed, when it will be found that rooting has taken place. In from 6-7 weeks (when sufficient roots have been produced) the shoots are taken out and replanted in pots ; at the end of the season each plant will have developed into a small well-rooted ' set '. One hundred per cent. ' take ' is usually obtained."

Glasshouse accommodation is unlikely to be available for propagation by soft-wood cuttings on an extensive scale ; in addition, it is essential that the labour of potting up and transplanting be eliminated. It was decided therefore to see if the cuttings would grow when planted directly into cold frames of simple construction in the open, and also if the ordinary commercial varieties and the new wilt-resistant varieties could be raised by this method. The experiments described below are a first attempt at answering these questions.

Frames, Compost and Cultural Treatment.

Frames 18 in. deep, to carry 6 ft. by 4 ft. lights, were made of rough elm boarding 1 in. thick. These were set out on a sheltered site. A slight slope to the North was achieved by letting the frames into the ground. The soil inside was then forked over and levelled, and a 4 in. layer of compost placed in each frame. The compost consisted of 1 part by volume coarse sand and 3 parts granulated horticultural peat to which sufficient ground chalk had been added to give a pH value of 6. Before mixing, the peat was thoroughly wetted by watering and stirring with a fork. If allowed to dry out, it was found very difficult to wet it again without much stirring, so after placing in the frames it was shaded, even before the cuttings were inserted, to conserve the moisture. Each frame was well watered in the morning before planting.

As soon as the cuttings were inserted, the lights were closed and each frame shaded with hessian. The frames were kept closed for about a week and then gradually given increasing ventilation until, about 8 weeks after planting, the lights were removed completely. The compost was kept consistently moist by daily watering and the cuttings shaded from direct sunlight until well established and in no further danger of wilting. When there was sufficient growth to need support, small sticks were provided for each plant, and these were later replaced by a system of nursery stringing supported on stakes outside the frames.

A dressing of meat and bone meal was applied to all frames about 8 weeks after planting. Nicotine sprays were used to control an outbreak of aphis at the end of June and early July ; and a proprietary copper spray was applied in July to prevent Downy Mildew. Hop Mould attacked all the plants in the late summer and dustings with flowers of sulphur were given in an attempt to control this. Watering was decreased, and finally discontinued, towards the end of the growing season, when the established plants were assumed to have rooted well into the underlying soil and the shade provided by the foliage prevented the rapid drying of the compost.

Basal Cuttings.

Material.

All cuttings of the variety Fuggle were from a plot of the best East Malling clonal Fuggle (Beard, 1943*b*). For the purpose of Trial 1, half the hills in the plot were lightly earthed up early in April. All the hills received some earthing during the normal cultivation later in the month, but this occurred too late to cause much etiolation or rooting of the shoots on the previously " unearthed " hills. Thus, when basal shoots were pulled at the beginning of May, there were blanched shoots with 2-3 in. of etiolated stem from the " earthed " hills, and " unblanched " shoots with little or no etiolated portion from the unearthed hills.

The four varieties (OR55, OJ47, AEE55 and OM26) used in Trials 2 and 5 are New Varieties raised by Professor Salmon, at Wye, and found to be resistant to Verticillium Wilt by Dr. W. G. Keyworth, of East Malling. In order to " blanch " the shoots for Trial 2, all hills of these varieties were lightly earthed up in April.

Preparation of Cuttings.

Basal shoots when pulled were taken into a cool shaded building for preparation. They were divided into long and short shoots. Each shoot was cut off above the second good node, and if the etiolated base was more than 3 in. long it was shortened to convenient dimensions. The cuttings were then graded for degree of initial rooting.

Records.

In all trials records of the growth of the cuttings were made at about fortnightly intervals after planting. At first the number of original leaves remaining was recorded and the number of nodes of the longest new shoots. Later, in place of old leaves, new shoots were counted, as well as the number of nodes of the longest such shoot. After about 6 weeks it was no longer possible

to count the shoots and nodes as the new bines became twisted together, so the records were discontinued, except for noting from time to time whether any more cuttings had died. Finally, at the end of October, the surviving plants were lifted and weighed individually.

It was observed that most of the cuttings shed all their original leaves within two or three weeks of planting. By the end of the fourth week most cuttings were either making new growth or were dead.

Trial 1.

To investigate methods of propagating Fuggle Hops by cuttings from surplus basal shoots, planted directly into simple cold frames. The eight grades of cuttings used, with a note on their relative rooting, are set out below :

Long blanched shoots, " rooted "—(very well rooted).
Short blanched shoots, " rooted "—(well rooted).
Long blanched shoots, " unrooted "—(poorly rooted).
Short blanched shoots, " unrooted "—(very poorly rooted).
Long unblanched shoots, " rooted "—(moderately rooted).
Short unblanched shoots, " rooted "—(moderately poorly rooted).
Long unblanched shoots, " unrooted "—(poorly rooted).
Short unblanched shoots, " unrooted "—(very poorly rooted or not rooted at all).
" Long " shoots =80-150 cm. long.
" Short " shoots =30-70 cm. long.

On 16th May, 20 cuttings of each grade were prepared, loosely tied together in 10's, and placed upright in 3 in. deep solution of β-indolyl butyric acid at 25 parts per million. The cuttings were left in the growth substance until the next day (18-20 hours) and then removed and rinsed in running water. In the morning of 17th May, a duplicate set of cuttings was prepared, but not treated with the growth substance. Thus there were eight grades of treated cuttings and eight grades of untreated cuttings, giving 16 treatments in all.

Planting.

The above cuttings were planted in the afternoon of 17th May in two frames. Each frame contained 16 randomized plots of ten cuttings and included each treatment once. It was not found possible to prepare enough cuttings for four frames in one day, so a third set of cuttings was prepared in the afternoon of 17th May and placed overnight in growth substance ; a fourth set (untreated with growth substance) was prepared in the morning of 18th May, and these two sets were planted in two frames in the afternoon of 18th May. In order to see whether time of " pulling " affected the growth of cuttings, four more frames were filled in the same way on 29th and 30th May, thus giving Time 1 and Time 2. The sets when lifted were weighed and placed in three categories : (1) sets fit for planting out in the hop garden, weighing more than 12 gm. and having adequate buds and a suitable proportion of stem and root ; (2) sets fit for replanting in the nursery, less than 12 gm. in weight, but otherwise sound ; (3) sets that were just alive, but had so little root that they were useless.

TABLE I.

TRIAL 1. PERCENTAGE USEFUL SETS FROM FUGGLE BASAL CUTTINGS (NO GROWTH SUBSTANCE).

	Long Rooted.	Long Unrooted.	Short Rooted.	Short Unrooted.	Mean.
Blanched ..	65·0	43·7	70·0	33·7	53·1
Unblanched ..	46·2	25·0	40·0	10·0	30·3
Mean	55·6	34·3	55·0	21·8	41·7

Mean all Long Shoots 45·0 Mean all Rooted Shoots 55·3
Mean all Short Shoots 38·4 Mean all Unrooted Shoots 28·0

Results.

The differences between the main treatments in this trial were of a very large order, so much so that no formal statistical analysis was needed. The mean percentages of useful sets (Grades 1 and 2) from treated and untreated cuttings were 11·7 and 41·7 per cent., showing that treatment with β-indolyl butyric acid at 25 p.p.m. was extremely harmful. Table I summarizes the percentages of useful sets obtained from cuttings *not* treated with growth substance. Cuttings from blanched shoots were definitely better than from unblanched shoots. Cuttings from long shoots were better than from short shoots and those with good initial rooting better than those with little initial rooting.

Cuttings from both long and short, blanched and initially well-rooted shoots produced a high percentage of useful sets (65 and 70 per cent.) ; but the former gave more sets fit for planting out in the hop garden.

The difference due to time of planting was hardly significant ; but an examination of the meteorological records showed that the first two frames were planted on a particularly warm day (17th May), and these gave a much lower " take " (mean 17 per cent.) than those planted the next day (mean 31 per cent.) or those planted 12 days later (mean 32 per cent.), all of which were planted in cooler weather.

Trial 1a.

It was soon apparent in Trial 1 that treatment with β-indolyl butyric acid was having a harmful effect. It was therefore decided at the end of June to make a small trial with what material remained, in an endeavour to find out if this adverse effect was due to the strength of the solution or to standing the cuttings overnight in a liquid.

Preparation and Planting.

Only sufficient material was available to provide cuttings for one frame. These shoots were pulled and 160 cuttings, as uniform as possible, were prepared. These were divided into 16 similar bundles of ten and four bundles subjected to each of the following treatments.

1. Placed upright in 3 in. deep water overnight (*c.* 18 hours).
2. Placed upright in 3 in. deep β-indolyl butyric acid at 5 p.p.m.
3. Placed upright in 3 in. deep β-indolyl butyric acid at 25 p.p.m.
4. Control. (These cuttings were kept turgid by folding between damp sacking overnight.)

All cuttings were planted on 27th June.

Results.

The variations between rows of the same treatment was too large for any statistically significant differences to be obtained from the few replicates. There were, however, indications that soaking in itself had no harmful effect and might even be better than leaving the cuttings overnight loosely covered in damp sacking. There was also an indication that β-indolyl butyric acid at 5 p.p.m. was less harmful than at 25 p.p.m., and might even be beneficial. The mean figures of plantable sets for the four plots of each treatment is given below :

	Per cent.
Untreated	15·0
Water only	25·0
β-indolyl butyric acid 5 p.p.m.	35·0
β-indolyl butyric acid 25 p.p.m.	17·5

Trial 2.

To ascertain if the four wilt-resistant varieties could be raised from basal soft-wood cuttings planted direct into a cold frame.

The grades of shoots used for cuttings are shown in the table below :

	Length.		Rooting.	
	" Long Shoots."	" Short Shoots."	" Well-rooted."	" Poorly-rooted."
	cm.	cm.		
OM26	100-150	40-70	Moderately rooted.	Nil to poorly rooted.
OR55	60-85	25-50	Very well rooted.	Poorly rooted.
OJ47	80-120	70	Slightly rooted.	Not rooted at all.
AEE55	80-120	60	,, ,,	,, ,,

Cuttings were prepared and planted on the same day. The first frame was filled on 11th May, the second and third frames on 14th May, and the last frame on 22nd May. Each frame contained all four grades of each variety in randomized plots of ten cuttings each.

The first frame was the first to be planted in any of these trials and was kept closed rather longer than the later ones. This caused a slight check to the cuttings when ventilation was begun.

Cuttings of AEE55 tended to lose their original leaves more completely and to begin new shoot growth more rapidly than the other varieties, but the new shoots were more liable to break off. Incidentally, the presence of four varieties within a single frame made it difficult to provide optimum

conditions of ventilation and shading for all. This trial again showed the need to avoid a very warm and sunny period for planting the cuttings. The frame planted on 22nd May, a cool day followed by a further drop in temperature, showed a mean take of 70 per cent., double that of the other three frames (34 per cent.), which were planted on a hot day (11th May) and a cool day (14th May) followed by a rapid rise in temperature on the three subsequent days.

The sets were lifted and graded as in Trial 1.

TABLE II.

TRIAL 2. PERCENTAGE USEFUL SETS FROM "WILT RESISTANT" VARIETIES (BASAL CUTTINGS).

Variety.	OR55.	AEE55.	OM26.	OJ47.	Mean.
Rooted	46·2	35·0	27·5	32·5	35·3
Unrooted ..	8·7	23·7	15·0	22·5	17·5
Mean	27·4	29·3	21·2	27·5	

Mean percentage from Long Shoots 63·5 Mean percentage from Short Shoots 65·5

Significant difference between Means, Long and Short or Rooted and Unrooted 14·4

Results.

Table II shows that cuttings made from shoots with good initial rooting gave more good sets; and these were on the whole larger than those produced by the cuttings from shoots with little initial rooting. OR55, OJ47, AEE55, and OM26 all propagated satisfactorily by cuttings made from such basal shoots. There was no difference between cuttings made from Long and Short shoots.

Lateral Cuttings.

Laterals were pulled off the bine between the bottom and breast wires only. Shoots of medium length and moderately short internodes, as uniform as possible were used. They were cut off above the second or third node, according to the length of the internodes, and the heel trimmed if it was long and ragged. Internodes of all prepared cuttings were measured and those with very long or short ones discarded. The second or "middle" cuttings used in Trial 5 were made from the remainder of the lateral by cutting it just below the next (third) node and just above the fifth node. These middle cuttings therefore each had three nodes and two internodes.

Trial 3.

To investigate the possibilities of propagating Fuggle from lateral cuttings.

The cuttings used had the following length ranges:

	2-node cuttings.	3-node cuttings.
First internode	3-11 cm.	2-5 cm.
Second internode	3-11 cm.	2-5 cm.
Third internode	—	2-5 cm.

In spite of these apparently wide ranges, there was very little variation in the total lengths of the cuttings.

Prepared cuttings were bundled in tens, with roughly equal numbers of two- and three-node cuttings in each bundle. In order to plant two frames in one day, 32 bundles of cuttings were prepared on 2nd July and two bundles placed overnight in 2 in. of each of the following solutions:

		p.p.m.			p.p.m.
1.	β-indolyl butyric acid at	5	9.	Phenyl acetic acid at ..	5
2.	β ,, ,, ,, ..	10	10.	,, ,, ,, ..	10
3.	β ,, ,, ,, ..	20	11.	,, ,, ,, ..	20
4.	β ,, ,, ,, ..	40	12.	,, ,, ,, ..	40
5.	β-indolyl acetic acid at ..	5	13.	α-naphthalene acetic acid at	5
6.	β ,, ,, ,, ..	10	14.	α ,, ,, ,, ..	10
7.	β ,, ,, ,, ..	20	15.	α ,, ,, ,, ..	20
8.	β ,, ,, ,, ..	40	16.	α ,, ,, ,, ..	40

The following morning eight similar bundles of cuttings were prepared as controls (not treated with any growth substance). They were all planted in the afternoon of 3rd July in two frames. Cuttings were planted only deep enough to keep them upright (about ½ in.). Two more frames were

filled in the same way on 5th July. All cuttings rapidly shed their original leaves. A few cuttings produced a little new shoot growth soon after planting, but within a month of planting, most were dead. On the whole the control cuttings survived longest; but all died eventually and only a few individuals, including some untreated with a growth substance, showed signs of having formed root initials when pulled up.

Trial 4.

To investigate the effect of different methods of applying growth substance to lateral cuttings of Fuggle.

Treatments.

Four bundles of ten cuttings were subjected to each of the following treatments :—

1. Placed upright in 2 in. deep water for 18 hours.
2. Placed upright in 2 in. deep β-indolyl butyric acid at 10 p.p.m. for 18 hours.
3. Bases dipped in dust of β-indolyl butyric acid.
4. Control untreated.

The dust was made up of 50 milligrams β-indolyl butyric acid in 100 gms. talcum. The base of each cutting was dipped in water and then in the dust immediately before planting. All were planted in one frame on 28th June.

Almost all the cuttings shed their leaves soon after planting, and very few of the cuttings survived more than two or three weeks. Of the few remaining when they were lifted on 1st November, only three in the whole frame were sufficiently big to be worth re-bedding in a nursery.

Treatment.	Per cent. Survival.
1. Water	7·5
2. Liquid	nil.
3. Dust	2·5
4. Control	2·5

Thus, neither trial gave a satisfactory method of propagating Fuggle from lateral cuttings. In both the growth substance was harmful, but apparently the adverse effect of treating with a liquid growth substance was not due to the soaking in liquid overnight, as those soaked in water only were slightly more successful than the untreated control cuttings or those treated with a dust.

Trial 5.

To ascertain whether the four wilt-resistant varieties could be raised from lateral cuttings and also to compare cuttings made from the middle portion of the lateral with those made from the basal end.

Cuttings used had the following length ranges :

Cuttings from base of lateral.

	OR55.	OJ47.	AEE55.	OM26.
	cm.	cm.	cm.	cm.
First internode ..	7-11	7-13	4-9	5-12
Second internode ..	5-10	5-9	4-8	5-10

Cuttings from middle of lateral.

	OR55.	OJ47.	AEE55.	OM26.
	cm.	cm.	cm.	cm.
First internode ..	5-11	5-10	5-14	5-10
Second internode ..	5-13	5-14	3-5	4-12

Two bundles of ten, of each kind of cutting were prepared and treated with β-indolyl butyric acid solution at 10 p.p.m. before being planted in one frame, on 29th June. Many of the laterals of OM26 and OJ47 turned out to be flowering shoots and produced burr, but did not readily make new shoot growth. When the surviving cuttings were lifted and weighed on 1st November, a few were found to have made plantable sets, but most required replanting in the nursery.

Results.

Generally lateral cuttings of these four varieties gave better results than those of Fuggle.

TABLE III.

TRIAL 5. PERCENTAGE USEFUL SETS FROM "WILT RESISTANT" VARIETIES (LATERAL CUTTINGS).

Variety.	OM26.	AEE55.	OJ47.	OR55.	Mean.
Middle	55	35	15	25	32·5
Base	35	30	0	0	16·2
Mean	45	32·5	7·5	12·5	

Differences with brackets not significant.

Table III shows that, on the whole, the middle type of cuttings proved the best, though basal cuttings of AEE55 gave a few sets fit for planting out. The heel of the basal cutting does not appear to be able to produce buds, so that there is a tendency for the sets to be "blind" when growth dies down to ground level in the autumn. This could be avoided by either deep planting or by a top dressing late in the season. The latter would probably be better.

General Conclusions.

Although some of the results have been negative and certain points require further investigation, these first trials in the large-scale propagation of hops from soft-wood cuttings have yielded some useful information. Both Fuggle and the four wilt-resistant varieties, Nonsuch Hop (OM26), OR55, OJ47 and AEE55 can be raised in simply constructed cold frames in the open from cuttings made from surplus basal shoots. These should be allowed to become reasonably mature (about 2 ft. 6 in. long) before removal from the hill. The results confirm the finding of Bailey (1939) that a light earthing of the hills as growth starts, ensuring that the bases of the shoots are blanched and have root initials, is very beneficial.

With Fuggle shoots of this type, about 50 per cent. of sets fit for planting out and about 16 per cent. suitable for growing on in a nursery for a season were obtained. With the exception of OR55, the percentage of plantable sets produced by the wilt-resistant varieties was lower. However, these were not planted on the same dates as the Fuggle and the presence of four varieties in one frame made it impossible to provide the optimum conditions for all.

There appears to be a fairly long period during which the basal cuttings can be taken, though—if unduly delayed—the shoots become tangled and are difficult to separate without damage. This could be obviated by training the bines up a special string or strings. More important than the actual time of taking the cuttings are the weather conditions at the time. As far as is practicable the cuttings should not be made and planted during a very warm and sunny period. Pending further research, treatment of the basal cuttings with a growth substance is not to be recommended.

Lateral cuttings of the Fuggle were a complete failure. However, it is interesting to note, in view of the fact that Bailey obtained no rooting of lateral cuttings without treatment with a growth substance, that some untreated cuttings formed a few small roots and a few survived until lifting. Treatment of Fuggle lateral cuttings with a growth substance was no more successful than in the case of basal cuttings.

Lateral cuttings of the wilt-resistant varieties were more successful; in this trial all were treated with β-indolyl butyric acid 10 p.p.m. Of the four varieties, Nonsuch Hop (OM26) and AEE55 were the best.

Cuttings of OR55, OJ47 and OM26 made from the middle portions of the laterals gave much better results than those from the base, indicating that rooting took place more readily from a node than from the heel.

Discussion.

It is evident that further work is necessary on the response of hop cuttings to growth substances, especially in view of the conflict between the results obtained by Bailey (1939), with much higher concentrations,* and those of the present series of experiments. It may be that there are definite varietal differences in response to growth substances and there is some evidence in support of this from a trial with strap-cuts (Beard, 1943*a*), in which Bullion Hop responded favourably to treatment, whilst Fuggle was adversely affected. A trial is now being carried out, using basal and lateral cuttings of Fuggle, a Golding and Bullion Hop, to clear up this point. The inclusion of a Golding will show

* Bailey used β-indolyl acetic acid at 200 p.p.m. and phenyl acetic acid at 500 p.p.m. for basal cuttings at the "asparagus" stage. For laterals he used β-indolyl acetic acid at 100 p.p.m. and α-naphthalene acetic acid at 50 p.p.m.

how this class of hop reacts in comparison with the other two. H. H. Glasscock in a letter states that, at Wye, lateral cuttings of Canterbury Golding treated with β-indolyl butyric acid failed to root, though similar cuttings of Brewers' Gold rooted.

Further trials are now in progress to elucidate these and other points arising from this season's preliminary work.

Acknowledgements.

The writers are indebted to Mr. R. J. Garner, and Mr. W. Corbett (Principal of the Kent Horticultural Institute, Swanley) for advice on several aspects of propagation by soft-wood cuttings. Dr. E. S. J. Hatcher of the Imperial College gave much assistance in the choice and strength of growth substances, and Dr. N. H. Pizer of The College, Wye, kindly estimated the pH value of the peat used, and advised a suitable addition of ground chalk. Mr. T. N. Hoblyn was responsible for the layout of the experiments, and Mr. S. C. Pearce made statistical analyses of the data.

Summary.

An account is given of some preliminary trials on the propagation of hops from soft-wood cuttings. Five main experiments were undertaken, in which basal and lateral cuttings of Fuggle and four Verticillium Wilt resistant varieties were tried. Other factors included were: long and short basal shoots from earthed and unearthed hills, selected for the presence or absence of initial rooting, time of taking and planting cuttings, the portion of lateral shoot used and the use of growth-promoting substances applied both as a liquid and as a dust.

Basal Fuggle cuttings made from long (i.e. mature) shoots from earthed hills and having initial rooting produced the highest number of plants. Treatment with β-indolyl butyric acid was very harmful. Time of planting had no significant effect.

The four wilt-resistant varieties can be propagated from basal cuttings. Cuttings with some initial rooting gave best results. The difference in favour of cuttings from long shoots was not conclusive, neither were the varietal differences.

Lateral cuttings of Fuggle were unsuccessful and treatment with a growth substance hastened death.

The harmful effect of the growth substance was not due to soaking overnight. Plain water was not harmful and may have even been slightly beneficial. Dust treatment with growth substance was less harmful than liquid treatment.

Cuttings made from the middle portion of laterals of the wilt-resistant varieties generally gave much better results than those with a heel. There were varietal differences.

References.

Bailey, C. R. (1939). "Some preliminary experiments in the use of root initiating substances in hop propagation." *J.S.-E. Agric. Coll.*, **44**, 47-53.

Beard, F. H. (1943*a*). "Propagation trials with Hops. I. The effect of treating cuttings (strap-cuts) with a growth substance before planting." *Rep. E. Malling Res. Sta. for 1942*, 68-70.

——— (1943*b*). "Commercial varieties of Hops. A preliminary comparison of their chief characteristics at East Malling." *Rep. E. Malling Res. Sta. for 1942*, 76-83.

PROPAGATION TRIALS WITH HOPS.

III. A COMPARISON OF THE PERFORMANCE OF CUTTINGS MADE FROM RUNNERS, LAYERS AND "STRAPS".

By F. H. BEARD

THE normal method of raising hop plants in this country is by means of "straps" or "strap-cuts". These are the swollen bases of the bines and are formed by earthing up the plants (hills) during the summer. During the dormant season the soil is removed and the "straps" cut hard back to the crown of the rootstock. This is a routine operation and is carried out whether or not the straps are needed for propagation. In some circumstances a number of natural underground runners are produced. These are not often used in this country, but are the normal means of increase in America. The reason for this difference in the choice of material probably lies with the different methods of cultivation practised and the varieties grown. In America, the hills are not earthed up, so that good "strap-cuts" would not be obtained, whilst either the method of cultivation or the varieties grown appear to favour a higher production of runners than is usual in England. At East Malling, cuttings made from runners have been used when present and the greatest possible increase in stock has been desired.

A few growers have in the past used layering as a rapid method of increase, and the method is now recommended (Beard, 1944) for the intensive propagation of those new varieties of which there is only a small nucleus and also, in conjunction with special hop nurseries, for raising healthy stock of the older varieties. As no data existed as to the number and size of the sets produced from runner and layer cuttings, it was desirable to compare their performance with that of the usual strap-cuts. The data obtained from trials made as opportunity occurred during the past few seasons are reviewed in this paper.

Natural Runners.

These are not usually more than 2 feet in length. They are close jointed, so that when made into 4-5 inch cuttings, each cutting has several nodes. They are planted in shallow "grips" similarly to strap-cuts, care being taken to see that the buds are pointing upwards. The top of the cutting is kept just below ground level. Comparison of runner cuttings and strap-cuts was made in 1943 and 1944. In the first season, the trial consisted of three randomized plots of 100 cuttings of each type. The variety used was Quality Hop (0063). In 1944 Fillpocket (Z62) was used and there were four replicates of 50 cuttings of each type in the trial. It was not possible to use the same variety in each season or to use both in the same season owing to lack of material. The sets in both seasons were lifted in November, graded and weighed. Two grades were made, those fit for sale or planting out into the hop garden and those too small for this purpose. Some of the small sets could, if needed, be replanted in a nursery for a further season, whilst others were quite useless. For practical purposes only the number of saleable sets produced need be considered. It should be mentioned here that there is an inevitable bias in the records of the weight of the sets. The larger the set, the more will be left behind in the ground with the ordinary method of lifting.

TABLE I.

STRAP-CUTS AND RUNNER CUTTINGS. NUMBER AND WEIGHT OF SETS PRODUCED.

Season.	Variety.	Type of Cutting.	No. of Small Sets. %	No. of Good Sets. %	Weight of 100 Good Sets. lb.
1943	Quality Hop (0063)	Strap-cuts.	7·0	92·0	20·4
	,, ,,	Runner Cuttings.	7·0	91·0	14·7
1944	Fillpocket (Z62)	Strap-Cuts.	4·5	78·5	18·1
	,, ,,	Runner Cuttings	10·5	78·5	16·4

The results are summarized in Table I. In 1944, the " take " was exceptionally good and there was no difference between strap-cuts and runner cuttings in either the total number of sets or the percentage of good sets. The runner cuttings did, however, produce smaller sets, 100 such sets weighing 14·7 lb., as compared with 20·4 lb. for 100 strap-cut sets. In the second season the " take " was not so good, but again both types of cutting produced equal proportions of good sets. Runner cuttings produced more small sets. The difference in set size, between the two types of cuttings, as shown by the weights, was suggestive, but just not large enough to be statistically significant.

Layer Cuttings.

During the summer of 1944, four of Professor Salmon's New Varieties were layered and in February, 1945 these layers were uncovered and cut into lengths of about 4-5 in. It was usually possible to obtain only one node to a cutting. The layers were cut so that this node should come in the middle of the cutting. The trial consisted of ten randomized plots of both strap-cuts and layer cuttings of College Cluster (N15 *bis*), Brewer's Standby (HH44), Brewer's Gold (C9a), and Bullion Hop (Q43).

The sets were lifted in November, 1945, and graded and weighed as in the previous trial. The results are summarized in Table II.

TABLE II.

STRAP-CUTS AND LAYER CUTTINGS. NUMBER AND WEIGHT OF SETS PRODUCED.

Variety.	Type of Cutting.	No. of Small Sets. %	No. of Good Sets. %	Weight of 100 Good Sets. lb.
College Cluster (N.15 *bis*) ..	Strap-Cuts.	11·5	77·5	17·3
" " " ..	Layer Cuttings.	20·0	62·0	13·5
Brewer's Standby (HH44) ..	Strap-Cuts.	13·5	79·0	12·0
" " " ..	Layer Cuttings.	16·0	71·5	10·0
Brewer's Gold (C9a)	Strap-Cuts.	18·0	78·5	14·6
" " "	Layer Cuttings.	19·0	74·5	11·1
Bullion Hop (Q43)	Strap-Cuts.	14·5	74·5	13·8
" " "	Layer Cuttings.	16·5	74·0	11·0

College Cluster and Brewer's Standby strap-cuts produced significantly more sets than layer cuttings. With Brewer's Gold and Bullion Hop, the differences were not significant. Layer cuttings of College Cluster produced about twice as many " smalls " as did strap-cuts. With the other varieties there was not much difference in the number of " smalls ".

In all varieties layer cuttings produced smaller sets (as shown by their weight) than strap-cuts. Varietal differences were present: College Cluster layer cuttings produced fewer sets than layer cuttings of the other varieties. This variety also produced larger sets, both from strap-cuts and layer cuttings than the other varieties. Brewer's Gold and Bullion Hop produced larger sets than Brewer's Standby. Differences among a wide range of varieties are under investigation.

Discussion.

These trials have confirmed the writer's belief that excellent results can be obtained with cuttings made from natural runners and layers, though cuttings made from layers may give a slightly lower " take " than strap-cuts. Any slight reduction in the " take " of layer cuttings, as compared with strap-cuts, is more than compensated for by the large number of cuttings that can be produced from the parent hill (50-75) contrasted with the few strap-cuts obtained (5-8). Though the sets produced by both runner cuttings and layer cuttings are smaller than those produced by strap-cuts, they are large enough for sale or planting out in the hop garden. There is no advantage in very large sets, as they are liable to suffer considerable " root-pruning " or even mutilation when lifted by the ordinary methods.

Full use should be made of natural runners when they are available and the maximum increase of stock is needed. Those who are now using the layering method for intensive propagation can expect a " take " little less than that obtained from strap-cuts.

Acknowledgements.

Mr. S. C. Pearce was responsible for the layout of the trials and made statistical analyses of the data. Miss D. J. Wilson graded and weighed the sets in 1945.

Summary.

An account is given of comparisons made between strap-cuts, runner and layer cuttings.

Runner cuttings were found to yield as many sets fit for planting in the hop garden as strap-cuts though they were smaller. Layer cuttings gave in some cases a small but significant decrease in the number of good sets compared with strap-cuts. This decrease was more than balanced by the large number of cuttings produced from the parent plant by layering. Layer cuttings, like runner cuttings, produced smaller sets than strap-cuts. It is suggested that there is no advantage in producing very large sets and that those produced from the runner and layer cuttings are amply large enough.

Reference.

Beard, F. H. (1944). "Intensive Methods for the Propagation of Hops." *Rep. E. Malling Res. Sta. for 1943*, 112-14.

OBSERVATIONS ON THE INCIDENCE OF MOULD *(SPHAEROTHECA HUMULI)* ON THE NEW SEEDLING HOPS AT EAST MALLING IN 1945

By F. H. BEARD

Hop Mould (*Sphaerotheca humuli**) is one of the oldest known hop diseases, and at one time was, together with aphis (*Phorodon humuli*), responsible for the wide fluctuations in yield that occurred from year to year. Since the adoption of dusting with sulphur as a control measure, the disease has become much less prevalent. However, " mould years " do occur from time to time when, owing to seasonal conditions, the routine dustings are either neglected or inadequate and fail to control the disease in some gardens. The seasons 1920 and 1945 were both remarkable for the prevalence of mould, but only in the latter year was there a serious outbreak in the Research Station gardens. Salmon (1921*a*) states that, in wet weather, dusting with flowers of sulphur often fails to control the disease and attributes this to the fact that rain washes off the sulphur particles before they have had time to act. Blodgett (1915) found that mould appeared after wet periods, and that under the conditions prevailing in New York State, leaf infections occurred 10-14 days after a rainy period. At East Malling, in 1945, the July and August rainfall was about average for the past 30 years but, during the last three weeks of July, there were 13 days and, in August, 20 days on which rain fell, and the weather was generally dull and somewhat cool. The unsatisfactory weather conditions of the season were reflected in the unduly prolonged burr period, nearly all varieties being in burr for around 10 days longer than usual. It is well known that a long burr period greatly increases the risk of mould attack on the developing cones. Salmon (1921*b*) stressed the need for early sulphuring to check the initial outbreaks arising from the winter spores. A long run of seasons without any

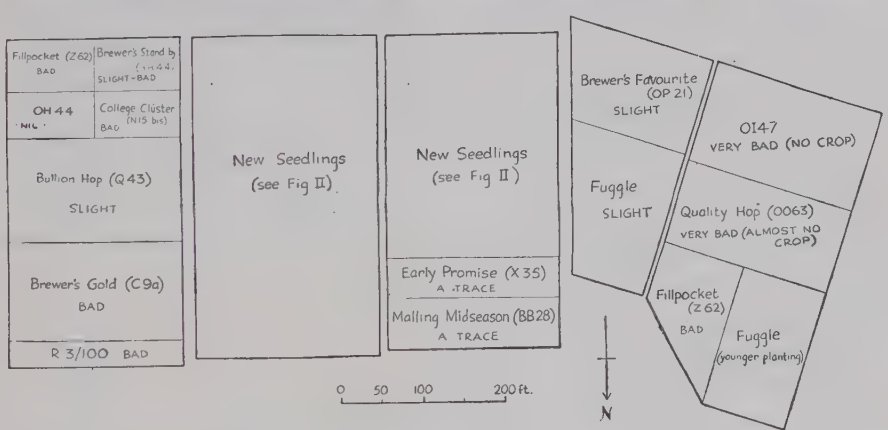


Fig. 1. General Plan of Main Hop Garden 1945. Severity of Mould Attack.

outbreak of mould had led to the omission of these earlier applications. In 1945, thorough dustings with flowers of sulphur were made on 6th-7th July and 12th-13th July, but little control of the disease was subsequently obtained.

Only the main garden of New Varieties and Fuggle was attacked, the small garden of Goldings at Bradbourne, about $\frac{3}{4}$ mile distant, was unaffected. The Bradbourne garden was badly attacked by aphis during June, and received a good washing with nicotine and proprietary spreader. The main garden was free from aphis and therefore received no washing. This may possibly have had some effect on the incidence of mould in the two gardens. Both gardens did, however, receive similar dustings with flowers of sulphur. The main hop garden at the Research Station covers some $8\frac{3}{4}$ acres, of which about $3\frac{1}{2}$ acres are planted with some 200 New Seedlings (raised by Professor Salmon at Wye) in short rows of 14-16 hills, the remaining area being occupied by larger plantings of selected New Wye Varieties and three clonal strains of Fuggle. The general layout of the main hop garden is shown in Fig. 1. It will be convenient to deal separately with the incidence of mould in the two portions of the garden.

* Formerly known as Powdery Mildew.

Incidence of Mould amongst the short rows of New Seedlings.

A casual inspection of the garden at the end of August left no doubt as to there being great differences in the severity of attack. The cones on some varieties were completely free from disease whilst those of adjoining rows were severely attacked. A survey of the garden was made and the severity of the attack on each variety noted. Fig. 2 shows the position of the various rows of seedlings together with the severity of attack. Six grades of severity of infection were made :

1. Attacked in burr stage, so that the crop failed to develop except for a relatively few cones.
2. Developed cones very severely attacked, so that they were not worth picking or could only be " picked over ". (" Very bad.")
3. Developed cones severely attacked. (" Bad.")
4. Developed cones only slightly attacked. (" Slight.")
5. Developed cones with only a trace of infection. (" Trace.")
6. Cones entirely free from disease. (" Nil.")

It is obvious that if affected hops were allowed to remain for long unpicked the cones would become more seriously attacked. For example, a variety classed as "Bad" at the end of August might be

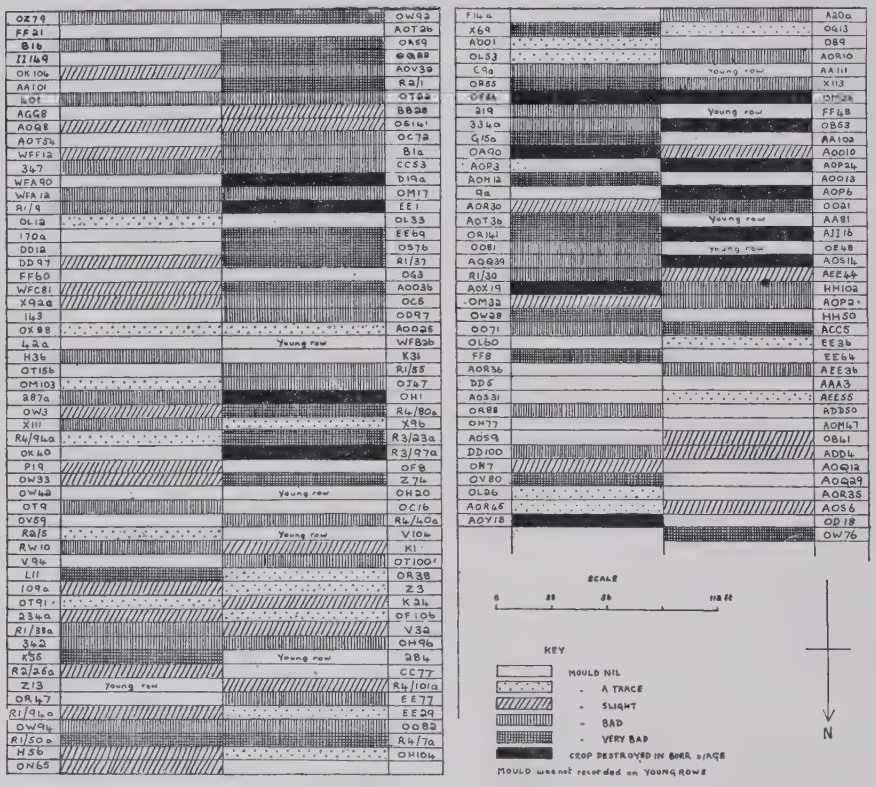


Fig. 2. Severity of mould infection on Cones of New Seedlings 1945

"Very bad" later in September, or a seedling classed as "Slight" in August might be "Bad" or "Very bad" later in the season. In order to harvest the maximum crop those seedlings showing mould infection in " Very bad " or " Bad " grades were, if not too unripe, picked first, followed by the less severely attacked seedlings. However, further observations on the disease at picking time were made and the grading made at the end of August revised where necessary. Seedlings showing no infection were, in order to gather the bulk of the mould affected ones, left unpicked for longer than they would be normally, so that those seedlings graded as " Nil " were truly resistant to mould infection in 1945. No records were taken upon leaf infection, but two varieties OJ47 and Quality Hop were noticed to have leaf infections earlier in the season (June). However, there is some evidence that the widespread attack on the burr and cones did not entirely arise from these sources of infection, but spread in from some outside source on the south-west winds. In Fig. 2 it will be seen that there are more seedlings severely attacked on the western side than on the eastern, and the attack on those varieties in larger plots on the extreme east of the whole garden (see Fig. 1), Brewer's

Gold, Bullion, College Cluster, Brewer's Standby, etc., developed later than the attack on the rows of new seedlings.

The data are reviewed in this paper to see whether either susceptibility or liability (e.g. due to season of burr) could be correlated with the parentage groups.

By " susceptibility " is meant an inherent genetical character of the plant which makes it likely to become infected by the spores of the disease. By " liability " is meant character of growth or season which renders it more likely to be attacked. For example, a strong growing variety making dense bine growth will be more liable to attack than a weaker variety, owing to the " housed in " condition of the bine preventing a good circulation of air, and also preventing the thorough penetration of the sulphur particles when the bine is dusted. A variety in burr at a time when mould infection is prevalent will naturally be more liable to attack in this vital stage than varieties which are in burr either earlier or later. However, in the present outbreak, date of burr does not seem to be a factor in determining the severity of attack, as no correlation between the dates of coming into burr and the duration period with severity of infection could be established. Susceptibility can only be ascertained by controlled inoculation experiments. The variation in incidence of the disease described in this paper may be due to differences in susceptibility or liability or both.

The parentage groupings are necessarily imperfect, as in many cases the female parent was open pollinated and the male parent therefore unknown. Incidentally many of the males growing in Professor Salmon's breeding ground at Wye are of American or hybrid origin, so that traces of American origin may appear in seedlings from that source, where open pollination occurred. It must also be remembered that the seedlings undergo a severe preliminary selection at Wye and that only the more promising ones are sent on for testing at East Malling. The seedling varieties growing at East Malling, therefore, only represent a small proportion of the original families, and if any correlation exists between susceptibility to mould and such factors as fruitfulness or amount of soft resins, there may be a definite bias in the East Malling data. For the above reasons too much importance must not be attached to any apparent correlation between the various parentage groups and susceptibility or liability to mould.

In 1945, 181 seedlings of two seasons growth or more were growing in the garden. Out of this number, 13 were attacked in the burr stage and bore no crop ; 28 were very severely attacked on the cones ; 44 were badly attacked ; 30 were slightly attacked ; 22 had only a trace of mould on the cones ; whilst 44 were entirely free from disease. Table I shows the number of varieties in the principal parentage groups graded according to severity of attack.

TABLE I.

INCIDENCE OF MOULD IN THE VARIOUS PARENTAGE GROUPS.

Parentage Group.	No. of Seedlings in Group.	Crop destroyed in burr stage.	Very Bad.	Bad.	Slight.	Trace.	Nil.
First generation from New Mexican hop ..	18	5	5	6	2	—	—
Second generation from New Mexican hop ..	9	—	1	5	1	2	—
Third generation from New Mexican hop ..	23	2	1	5	3	4	8
First generation from wild hop, Manitoba ..	18	—	8	5	4	1	—
Second generation from wild hop, Manitoba	43	3	4	10	7	7	12
Third generation from wild hop, Manitoba ..	8	—	1	—	2	2	3
Second generation from Oregon Cluster ..	5	—	—	2	3	—	—
Third generation from Oregon Cluster ..	20	—	3	4	4	3	6
Fourth generation from Oregon Cluster ..	4	—	1	—	—	—	3
Bramling × male seedling of New Mexican hop	4	—	1	1	—	1	1
Bramling × male seedling of wild hop, Manitoba	8	—	2	1	3	—	2
Canterbury Golding × male seedling of Brewer's Gold (seedling of wild hop, Manitoba)	3	—	—	1	1	—	1
Seedlings of Golding hop (B20) of unknown unknown	7	—	1	2	—	—	4
Seedlings of Fuggle	3	—	1	1	—	—	1

Varieties derived from a wild New Mexican hop (*Humulus americanus var. neo-mexicanus*).

In 1915 Professor Salmon obtained plants from Mr. D. M. Andrews, Rockmont Nursery, Boulder, Colorado, U.S.A, under the name *Humulus lupulus var. neo-mexicanus*. Salmon and Wormald.

(1915) have pointed out that *neo-mexicanus* belongs to the indigenous American species *H. americanus*, as described by Nuttall (1847) and not to the European species *H. Lupulus*. Nothing is known as to its susceptibility to mould.

First Generation.

Seedlings in this group were nearly all severely attacked. Out of a total of eighteen, five were attacked in the burr stage, eleven were either severely or very severely attacked on the cones, whilst only two had slight infection of the cones.

Second Generation.

This group also had a large number of seedlings severely attacked. Out of a total of nine seedlings, six were severely or very severely attacked on the cones, one was slightly attacked and two had only a trace of infection.

Third Generation.

This group shows a much wider range of attack. Out of a total of twenty-three seedlings, eight were classed as bad or very bad, two of which were severely attacked at the burr stage, three were slightly attacked, four had a trace of infection, whilst eight were completely free from disease.

Varieties derived from wild hop, Manitoba (*H. americanus*).

In 1916 Professor Salmon obtained through Professor Macoun cuttings of a wild hop growing at Morden, Manitoba, a district where cultivated hops had never been grown, so that the plant appeared to be a true wild specimen of *H. americanus*. Nothing is known as to this hop's susceptibility to mould.

First Generation.

This group has a similar range of incidence to the first generation from the New Mexican hop, except that none of the eighteen seedlings was attacked in the burr stage, and that five were either slightly attacked or had only a trace of infection.

Second Generation.

The forty-three seedlings in this group show a wide range of severity of attack, with nearly half showing only a trace of disease or being entirely free of infection. Three seedlings were attacked in the burr stage. There is no significant difference in the incidence of disease between the seedlings derived from the various first generation crosses (Brewer's Gold, Bullion Hop, 334a, etc.).

Third Generation.

There are only eight seedlings in this group and of these one was classed as very bad, four as slight or having only a trace of infection, whilst three were free from disease.

Varieties derived from the Oregon Cluster.

In 1908 Professor Salmon obtained cuttings from a plant growing in the Oregon hop gardens of Messrs. Wigan, Richardson & Co., Hop Merchants, London. The cuttings were labelled as coming from a male plant, but proved to be of a female commercial " Cluster " variety grown in Oregon, probably the variety known as " Late Cluster " or " English Cluster ". The " Cluster Hops " of Oregon are believed to be either a form of *H. americanus* or a hybrid between *H. americanus* and *H. lupulus*. In U.S.A. mould is said to be largely confined to the hop growing area of New York State. Blodgett (1915) states that, in New York State, the varieties in order of susceptibility to mould are Canada Red Vine, English Cluster, Humphrey and Native Red Vine. No first generation seedlings are now growing at East Malling.

Second Generation.

All five seedlings in this group are in the middle grades of severity of attack.

Third Generation.

The twenty seedlings in this group are fairly evenly distributed amongst the several grades of incidence, with nearly a third of them free from disease.

Fourth Generation.

There are only four seedlings in this group and of these one was very badly attacked on the cones and three were free from disease.

Seedlings of the parentage, Bramling × male seedling of New Mexican hop.

The four seedlings in this group are equally divided between the " very bad " (attacked in burr stage), " bad ", " trace ", and " nil " grades.

Seedlings of the parentage, Bramling × male seedling of Brewer's Gold.

Of the eight seedlings of this parentage two were very bad, one bad, three slightly attacked and two were free from disease.

Seedlings of the parentage, Canterbury Golding × male hop from Brewer's Gold (seedling of wild hop, Manitoba).

The seedlings noted here are three of the four varieties named and described by Salmon (1944), the fourth variety, Southern Brewer, is a " mosaic susceptible " at present being grown in isolation. Northern Brewer (WFA12) was classed as " bad ", Wye Field Golding (WFC81) as " slight ", and John Ford Hop (WFA90) was free from disease.

Seedlings derived from a Golding hop (B20) of unknown origin.

The seven seedlings in this group are about equally divided at each end of the scale.

Seedlings of the Fuggle.

These were all derived from open pollinated flowers and may, therefore, as mentioned earlier, have some trace of American origin. One was free from disease, one was attacked in the burr stage and the other had a bad attack on the cones. Professor Salmon considers that these two may have some American ancestry on the male side, as one has a definite " Manitoba " aroma and the other has unduly high α-resins for a variety of purely English origin.

Seedlings of various other Parentages.

In addition to the seedlings in the main parentage groups shown in Table I, there are eight others, but as there are not more than one or two in any one group, little information can be obtained of the incidence of mould upon them. They comprise the following parentages: Fourth generation from New Mexican hop, one badly attacked on cones. Early Bird × Oregon male, one attacked in burr stage. Seedlings of Bramling, two free from disease. Seedlings of Late Bavarian hop, one badly attacked and one with only a trace of infection. Seedlings of unknown origin, one with a trace of infection. Seedling of Golden Hop × male from Oregon, one free from disease.

Large Plantings.

Table II shows the incidence of mould amongst the larger plantings which are in self-contained blocks of from $\frac{1}{8}$-$\frac{1}{2}$ acre in extent, and Fig. 1, the relative position of the varieties and their relation to the garden of new seedlings.

TABLE II.

INCIDENCE OF MOULD ON LARGE-SCALE PLANTINGS.

Variety.	Parentage.	Severity of attack.
Brewer's Favourite (OP21)	Second generation from Oregon Cluster	Slight.
Brewer's Gold (C9a).	Seedling of wild hop, Manitoba.	Bad.
Brewer's Stand-by (HH44)	Seedling of Golding hop of unknown origin.	Slight-bad.
Bullion Hop (Q43)	Seedling of wild hop, Manitoba.	Slight.
College Cluster (N15 *bis*).	Second generation from New Mexican hop.	Bad.
Early Promise (X35)	Seedling of hop of unknown origin.	Trace.
Fillpocket (Z62).	Second generation from Oregon Cluster.	Bad.
Malling Midseason (BB28).	Second generation from Oregon Cluster.	Trace.
Quality Hop (OO63).	Third generation from Oregon Cluster.	Very bad, almost no crop.
OH44.	Second generation from Golden Hop.	Nil.
OI47.	Seedling of New Mexican hop.	Very bad, attacked in burr stage.
Fuggle Strain " N " established hills.		Slight.
Fuggle Strain " N " 2-year-old hills.		Trace.
Fuggle Strain " A ".		Slight.
Fuggle Strain " L ".		Slight.

Out of eleven New Varieties only two were very severely attacked, Quality Hop (OO63) and OI47. The former has been grown at the Research Station since 1929 and has never before suffered from mould, but, in 1945, it showed many leaf infections at the end of June. When planted out in a $\frac{1}{2}$ acre plot in 1937, OI47 was considered to be one of the best of the first generation seedlings

from the New Mexican hop, a heavy cropper with a very high P.V. However, of recent years, seedlings of this class of hop have given disappointing results at East Malling, and in only two seasons (1938 and 1944) has the large plot of OI47 borne a good crop. In 1939, the crop had to be picked prematurely owing to an attack of *Botrytis*, in 1940, 1941, 1942 and 1944 the cones never developed properly, and in the latter season they were also attacked by mould. Three varieties, Brewer's Gold, College Cluster, and Fillpocket were severely attacked, and two varieties, Brewer's Favourite and Bullion Hop were only slightly attacked. Early Promise and Malling Midseason had only a trace of infection on the cones. Only one variety, OH44, was entirely free from disease and this variety is derived from the " Golden Hop ", which is immune to mould (Salmon, 1920). Of the two varieties derived from the wild hop, Manitoba, Bullion Hop appears to be more resistant than Brewer's Gold. Out of the three second generation seedlings from the Oregon Cluster, one, Fillpocket, was severely attacked and one, Malling Midseason, had only a trace of infection. There was no difference in the severity of attack between the three clonal strains of Fuggle (all " slight "), though a younger planting of one strain was less severely attacked.

With the exception of Quality Hop and OI47 it seemed that the attack did not originate in the larger plantings, but spread from the badly affected varieties in the garden containing many varieties in short rows. That short rows of Brewer's Gold and Malling Midseason growing in the garden of New Seedlings were more severely attacked than the same varieties planted in mass, supports this theory.

Discussion.

A garden of many seedlings growing together in close proximity offers great facilities for the spread of diseases, as any particularly susceptible ones are liable to become attacked and pass on the infection to others nearby. Therefore the forty-four varieties (out of a total of 181) which remained free of mould must be considered to have very definite resistance to the disease.

Though nothing appears to be known of the susceptibility to mould of the two female parents, *H. americanus var. neo-mexicanus* and the wild hop from Manitoba, they appear to pass on to their progeny in the first generation a high susceptibility or liability to the disease. All these seedlings are very strong growers and hence have a greater liability to the disease. However, in succeeding generations a much wider range of incidence exists and amongst the third generation from New Mexican hop and the second and third generations from the wild hop from Manitoba, many of the seedlings were entirely free from mould in 1945.

No first generation seedlings of the Oregon Cluster are now growing in the gardens, and only a few second and fourth generation seedlings are present, but there are several third generation seedlings. On the whole, it seems that the seedlings derived from the Oregon Cluster behave somewhat similarly to those derived from the *H. americanus, var. neo-mexicanus* and from the wild hop, Manitoba, though, in the absence of any first generation crosses, it is impossible to obtain a true comparison.

In all the fourteen parentage groups given in Table I, except the first and second generation from the New Mexican hop, the first generation from wild hop, Manitoba, and the second generation from the Oregon Cluster, a substantial percentage of the seedlings remained free from mould in the generally severe attack of 1945 and so must be considered to be very resistant, if not actually immune. Salmon (1920) found that the female ornamental variety " Golden Hop ", which is of little brewing value and a weak grower, was immune to mould and passed on this character to many of its progeny. At the present time only two varieties, OH44 and K31, derived from the Golden Hop, are growing in the East Malling gardens, others having been discarded as possessing no outstanding brewing merit. OH44 is of the parentage (Golden Hop × English male) × English male, and K31 is a seedling derived from the Golden Hop crossed with an Oregon male. Both these varieties remained free from mould. It is interesting to find that many seedlings raised from parents not specially selected for mould resistance remained free from disease in a very severe outbreak.

There appears to be a tendency for heavy and poor cropping to be associated with a high and low mould incidence respectively. Taking an average yield of 18 cwt. per acre as the dividing line, the percentages of all varieties in the different " mould groups " which yield sufficiently well to have a commercial future are :

Mould Group	Very bad.	Bad.	Slight.	Trace.	Nil.
Per cent. Yielding over 18 cwt. ..	63%	44%	12%	19%	17%

This may be partly a question of liability but, since AGG8—probably the most vigorous variety in the garden—was entirely free from the disease, this cannot be the full explanation.

This association of high yields with susceptibility or liability to mould may help to explain the absence of mould resistance amongst both the older commercial varieties and the new Wye

varieties. However, amongst those seedlings which remained free from mould, there are five which are also heavy croppers (over 20 cwt. per acre) and three of these are of distinct commercial promise. The seedlings are detailed below :

OH44. (Second generation from the Golden Hop.) Regular cropper, good P.V., easy to pick ; has given satisfactory results in brewing trials. It is being grown commercially by two growers.

OH77. (Second generation from wild hop, Manitoba, via R3/100.) Regular cropper, good P.V., easy to pick ; deserves brewing trial.

AGG8. (Second generation from wild hop, Manitoba, via Brewer's Gold.) Regular cropper, fair-good P.V., very strong grower ; but the good bold cones are easy to pick when not more than one bine is put to each string ; deserves brewing trial.

F14a. (Third generation from Oregon Cluster.) Though the mean yield is over 20 cwt. per acre, the cropping has been rather irregular ; a few hills have died, presumably killed by Downy Mildew infection of the rootstock ; moderate P.V.

OB9. (Second generation from wild hop, Manitoba, via Brewer's Gold.) Only two seasons cropping records available ; good P.V. ; deserves brewing trial.

There are also two seedlings with a mean yield of over 18 cwt. per acre :

AOT54. (Third generation from New Mexican hop.) Mean yield 19·3 cwt. ; rather low α-resins when analysed in 1941 and 1945 ; deserves brewing trial.

AO89. (Third generation from New Mexican hop.) Mean yield 18·1 cwt. ; rather low α-resins when analysed in 1942.

FF21. (Seedling of Bramling.) Yielded at the rate of 19·8 cwt. per acre in 1945 and shows resistance to Verticillium Wilt ; should be a valuable hop if it maintains its yield in future years.

The eight New Varieties, raised and introduced into commercial cultivation by Professor Salmon and now being grown on an increasing scale, were selected during a period of years when mould was not in evidence. Thus 1945 provided the first opportunity of assessing their relative susceptibility. Whilst none was entirely free from disease, two of them—Brewer's Favourite and Bullion Hop—were only slightly attacked, and two –Early Promise and Malling Midseason –had only a trace of infection. As mentioned earlier, except in Quality Hop, the outbreak did not appear to originate on these eight varieties, but rather to have spread from the severely attacked varieties nearby. It should be emphasized that all eight varieties have been grown successfully for many years at East Malling without suffering from mould, nor have attacks on commercial plantings been recorded. There is therefore no reason to suppose that these varieties, with the possible exception of Quality Hop, are in any way more liable to attack by mould than the older varieties, Fuggle, Goldings, and Golding Varieties.

Acknowledgements.

The writer is indebted to Professor Salmon, Dr. W. M. Ware and Mr. H. H. Glasscock, of Wye College, for a number of helpful suggestions as to the presentation of data. Miss D. J. Wilson gave much assistance in summarizing and correlating the data.

Summary.

An account is given of a serious outbreak of Mould (*Sphaerotheca humuli*) among new seedling varieties of hops at East Malling in 1945. Of 181 seedlings in short row of about 15 hills, 13 were attacked in the burr stage and bore no crop, 28 were very severely attacked on the cones, 44 were severely attacked, 30 were slightly attacked, 22 had a trace of infection, whilst 44 were free from disease. There was a high mould incidence in certain parentage groups, notably the first generations from the wild New Mexican hop and the wild hop from Manitoba, forms of *H. americanus*. Other parentage groups, such as third generation from the New Mexican hop, second and third generations from the wild hop, Manitoba, and third generation from the Oregon Cluster had a number of seedlings which showed no sign of the disease.

Among the larger plantings of the named new varieties none was free from disease, though Early Promise (X35) and Malling Midseason (BB28) had only a trace of infection, whilst Brewer's Favourite (OP21) and Bullion Hop (Q43) were only slightly attacked. Brewer's Gold (C9a), College Cluster (N15 *bis*), Fillpocket (Z62) were severely attacked. Quality Hop (OO63) had the crop almost entirely destroyed.

There appeared to be a tendency for heavy cropping to be associated with high incidence and light cropping to be associated with resistance to mould. This may be due to liability as well as susceptibility, but—in the present observations—there was no means of separating the two factors. Brief notes are given on seven good cropping varieties which remained free of disease.

References.

Blodgett, F. M. (1915). "Further studies on the spread and control of Hop Mildew." *N.Y. Agri. Expt. Sta.*, Bull., 395.

Nuttall (1847). "Description of plants collected by William Gambell, M.D., in the Rocky Mountains and Upper California." *Acad. nat. Sci.*, I. (Sec. ser.), 181.

Salmon, E. S. (1920). "On forms of the Hop (*Humulus lupulus*) resistant to Mildew (*Sphaerotheca humuli*). IV." *Ann. app. Biol.*, **6**, 293-310.

——— (1921*a*). "Hop Mould and its control." *J. Minist. Agric.*, **28**, 150-7.

——— (1921*b*). "On forms of the Hop (*Humulus lupulus*) resistant to Mildew (*Sphaerotheca humuli*). V." *Ann. app. Biol.*, **8**, 146-63.

——— (1944). "Four seedlings of the Canterbury Golding." *J. Inst. Brewing*, **50**, 244-50.

———, and Wormald, H. (1915). "*Humulus americanus* Nutt." *J. Bot.*, **53**, 132-5.

Section IV

BULLETINS FOR FRUITGROWERS

THE DESSERT APPLE PLANTATION OF TOMORROW

WHAT TO PLANT AND HOW TO PLAN IT IN THE LIGHT OF PRESENT DAY KNOWLEDGE*

By T. N. HOBLYN

A LITTLE over a year ago Dr. Hatton, addressing a Conference of Growers in Maidstone, surveyed the problems that confront the would-be planter of fruit trees at the present time.† He reminded his audience of typical Kentish lay-outs of thirty-two years ago in the days of hand digging and hand hoeing, and of the economic and labour problems of the first Great War, which brought many such closely planted plantations to disaster before they ever had a chance to justify their existence. He then went on to describe broadly the main developments in our knowledge during the past thirty years and to show how they should influence the planning of future plantations.

Experience has shown many flaws in the lay-out of orchards as planted in those days or even in the nineteen-twenties. Few growers to-day would plant Cox on M. II at 14 or 15 ft. square or include Emneth Early or Stirling Castle as pollinators, as was then recommended. The grower today is confronted with social and economic conditions that have changed greatly in recent years and, in deciding what to grow and how to plan, he has to consider the probable situation seven or eight years, or even further, ahead. He must take into account the existing acreages of the different kinds of fruits, present and future trends in planting, the likely demands of the market and such like aspects. In the general planning of his plantation he has the findings of research as well as his own experience and that of his fellow growers to help him. There is, however, more than one road to success and he must make up his own mind which he will take, carefully considering his financial position, the situation, nature, and cost of his land, labour conditions following a second Great War, modern developments in machinery and many other pros and cons.

At present an increased acreage of dessert apples is needed by the country as a whole and this article is confined to this fruit. This does not mean that this is the only fruit crop which is worth the attention of the intending planter. Indeed the land and site available may be quite unsuitable for dessert apples. Further, in contemplating fruit planting, the discerning grower will note with interest the fall in acreage of culinary apples and plums that seems likely, if the tendency revealed by a study of the numbers of trees under nine-years-old in the 1944 Fruit Census is maintained, and the demand for pears and yet more pears. Furthermore, the present acreage of almost all small fruits shows plenty of room for expansion, as supplies of material certified free from disease and true to name become more plentiful.

For the purpose of this article, however, it is assumed that the grower has selected his site, with due regard to soil, aspect, air drainage, water supplies and all the other matters that must be taken into account, and has decided to grow dessert apples. What shall he grow and how should he plan his plantation ?

Varieties.

The *agreed list* of dessert apples, recommended for planting on a large scale by the National Farmer's Union, the Horticultural Trades Association and the Royal Horticultural Society, only includes four varieties—in order of ripening—Miller's Seedling, Worcester Pearmain, Cox's Orange Pippin and Laxton's Superb. Three more are recommended for more limited planting—Laxton's Epicure, Laxton's Fortune and Lord Lambourne. Serious defects in the shape of a trouble known as " rubbery wood " and a tendency to produce " chat " fruits have, however, developed in the last-named and, until more is known regarding the cause of these troubles and the possibility of controlling them, this variety should only be planted with extreme caution.

* Based on a paper read at a Conference organized by the Essex W.A.E.C. at Witham, 13th February, 1946.

† *See E. Malling Res. Sta. Annual Report* for 1944, p. 96.

Six more varieties are approved for particular purposes only—Allington Pippin, Beauty of Bath, Blenheim Orange, Charles Ross, Ellison's Orange and James Grieve.

There is endless opportunity for argument about the merits of the varieties in these lists, but, in the absence of some special reason, the main part of any new plantation should normally consist of one of the first four.

First of all it has to be remembered that all dessert varieties do not do equally well in all parts of the country, but respond differently to different conditions of soil and climate. Further, that their manurial requirements are not always the same, and that they may require different spraying treatment. Before planting up, all these factors must be carefully considered, both as regards the main varieties and in relation to the all important matter of varieties for pollination purposes.

At the present time the variety most generally favoured is undoubtedly Cox. Allowing for replacements of existing plantations that become over age, it seems likely, if the present planting tendency is continued, that the effective acreage of Cox in cropping in the whole of England will increase by about 58 per cent. during the present decade, whilst the acreage of Worcester Pearmain and other dessert varieties will be barely maintained. In Essex, nearly two-thirds of all the dessert apples planted during the eight years prior to 1944 were Cox, this variety accounting for half the whole dessert apple acreage in that County. The increase in Cox acreage in Essex seems likely to be somewhat greater than in the rest of England, while there will also be substantial increases in Worcester Pearmain and other varieties. This forecast, however, is necessarily tentative in the extreme, owing to the effect of war restrictions on planting during the past five years, but the tendency is unmistakable.

In former years Cox was considered the specialist's apple, only to be grown on particularly favourable soils, and the price was and has remained high. The large-scale plantings of the last 10 to 15 years have aimed at bringing this apple within the reach of the many. The amazing thing is the wide range of soils and climatic conditions in which this former specialist's apple can now be successfully grown ; and, if this means that the price can be so reduced as to suit the pocket of the average housewife, perhaps with a large family hungry for apples, then the markets will readily absorb the increased production and there is every reason to maintain the increase. However, while gas storage now enables the season of Cox to be extended until the end of March, there is no question of having it on the market all the year round. Therefore, there seems room particularly for an increase in dessert apples for the August, September and October markets (the earlier part of which at any rate the home grower should have more or less to himself) that trees now coming into bearing seem unlikely to provide. Miller's Seedling and Worcester Pearmain are the two main varieties recommended in the *agreed list* mentioned above for that season, with Epicure and Fortune for second choice.

Nearly one-quarter of the dessert apple acreage now in cropping in England is devoted to Worcester Pearmain and, although to the writer it seems desirable to maintain this acreage, there would seem a need for varieties to extend the season of Worcester, rather than a large increase in this variety itself. For this reason a new variety being distributed from East Malling for the first time this year, " Tydeman's Early Worcester ", which has many Worcester qualities and at East Malling can be harvested a fortnight earlier, seems well worth a trial under commercial conditions. Is it too much to hope that it will replace some of the green, immature Worcesters that annually find their way to the market, and spoil it for those who pick at the right season ?

Miller's Seedling has proved a valuable apple in Kent, but it tends to bear biennially and to set every blossom in " on " years and, for these reasons, only growers who can afford the labour for special pruning (and possibly bud-rubbing) in the winter and drastic fruit-thinning in the summer, are likely to attempt to grow a large area of this variety. Laxton's Epicure is a good quality apple, but needs a quick trade, while Laxton's Fortune is quite the most promising of the newcomers in the late Worcester season.

Last of the " big four ", Laxton's Superb is another rather difficult variety that is inclined to biennial bearing, and probably requires rather special pruning and manurial treatment if it is to bear regularly and produce crops of high quality fruit. If the Cox acreage is increased and cold or gas storage available, the need for Superb is not so apparent, but, for growers who lack these facilities, it is a valuable apple to follow after Cox.

Of the last six which are recommended for particular purposes, only Ellison's Orange, despite its tendency to have a flavour of aniseed, deserves mention as a regular cropper, with the reputation of being resistant to frost. It is, moreover, valuable as a pollinator for Cox.

The planting of James Grieve, in many ways an ideal pollinator variety because of its regular blossoming, is frequently ruled out owing to its proneness to brown rot.

One other variety, not yet included in any list of recommended varieties, which appears to be coming to the fore, is Sunset. Though not a great deal is known at present regarding its performance in the plantation, in view of the favourable reports that are being received, it may be worth inclusion

on a small scale. Of Cox parentage, it ripens somewhat earlier and is suitable as a pollinator for that variety.

At the moment then the choice for the majority would appear to be between a plantation consisting mainly of Cox, interplanted with suitable pollinators, or one of Worcester Pearmain, interplanted with varieties selected with a view to extending its season.

Pollination.

The importance of really efficient pollination is not always adequately realized and, until recently, too little attention was paid to this important matter, the tendency in many cases having been to cut down too drastically the proportion of pollinators and rely too much on one variety. Time and time again in recent years it has been the mixed plantation that has yielded the crops after an inclement blossoming season, and, whilst we may not be able to say for certain what causes the excessive drop in Cox, for example, that often takes place in the June period or even later, inadequate pollination may well be one cause, and it would therefore seem advisable to err on the safe side and be generous with pollinators, choosing two or even three varieties for the purpose. To the writer one pollinator in nine, the commonly accepted proportion, seems inadequate. The following plan (see Fig. 1), which is similar to that adopted by a well-known Kentish grower for a new "Cox" plantation, has much to recommend it :

For every twelve rows :

8 rows of Cox.
2 rows of Worcester or Ellison's Orange.
1 row *each* of two of the following—Laxton's Superb, Fortune or Sunset.

i.e. three pollinating varieties in the proportion of one pollinator to every two Cox trees. Each row consists of one variety only and the rows are arranged in the following order—two rows of Cox, then one row of a pollinator, two more rows of Cox, one of another pollinator, and so on. By growing varieties separately in rows it is more easy to cater for their individual manurial requirements.

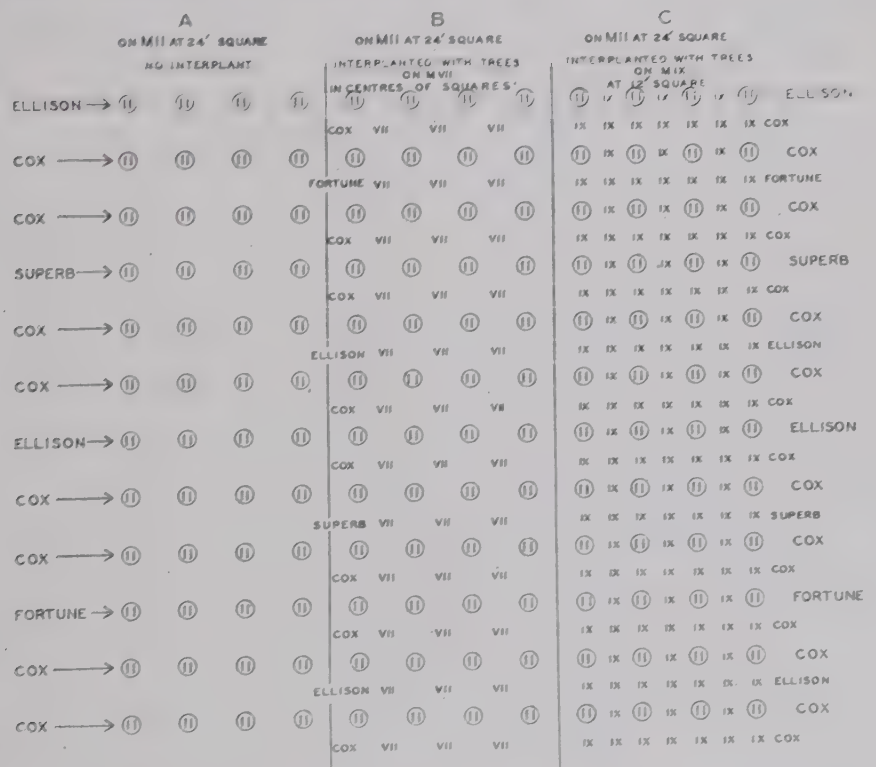


FIG. 1.

Diagram illustrating suggested layout of Cox plantations, with and without temporary filler trees, showing distribution of pollinator varieties.

Note.—In plantation C, the tree on M. IX in the centre of each square, may be replaced by one on M. VII if preferred.

In this plan Worcester may be substituted for Ellison, if the latter variety is not liked. As regards the other three varieties, the time of blossoming coincides with Cox and all are diploids, the two essential qualities, but we cannot be sure enough of their regular blossoming as yet to rely on one of them alone for pollination purposes.

The Worcester plantation may be planned in a similar way with possibly fewer pollinator varieties, since Worcester is to a certain extent self-fertile.

System of Planting.

Before the war the grower had several choices open to him in the planting system and kind of tree he selected for dessert apples :

Cordons.
Dwarf bushes.
Dwarf pyramids.
" Normal " bushes (2 ft. to 2 ft. 6 in. leg).
Half-standards (4 ft. 6 in. leg).

Today, cordons and dwarf pyramids, at from 2,000-3,000 trees per acre, are ruled out for commercial purposes by the scarcity of trees and high prices ruling, both for trees and necessary supports. It has recently been estimated that the initial cost of planting 3 acres of dwarf pyramids on M. II rootstock, which do not need stakes, at 6 ft. by 3 ft., is £483 per acre, not including the cost of land. This assumes that the holding is a new one and that the grower starts from scratch ; but nevertheless, however much we may admire them, it would seem that for the present these forms of trees must perforce be kept for the garden.

The smallholder may still be attracted by the idea of dwarf bushes on M. IX rootstock at, say, 12 ft. by 8 ft. or 12 ft. square. The initial cost is not nearly so high, but it must again be emphasized that, to manage *permanent* plantations on M. IX successfully, the grower must be prepared to take trouble over his trees, to stake them carefully and support the branches when cropping, and to cultivate and manure them generously. Properly cared for, they will continue to grow and crop for 30 years and upwards, and will average a bushel of highquality fruit a year, which incidentally, if picked at the right time, should keep for as long a period as any other, though, since it must be harvested earlier, it will naturally mature earlier.

Generally speaking the kind of fruitgrowing that asks for trees on a 4 ft. 6 in. or 6 foot leg is not for the grower of high quality dessert apples, since all the essential operations, viz. careful pruning, spraying, fruit thinning and picking, are more expensive and difficult. He is therefore left with the bush tree on a 2 ft. 9 in. to 3 ft. leg, rather longer than was once the wont to facilitate tractor cultivation, as the most practicable form of tree for the commercial grower today.

Rootstock.

What rootstock should be chosen on which to work this type of tree ? At present the choice is more or less limited to three Malling selections, M. I, M. II and M. XVI, and rootstocks raised from seed imported from America. Of the other Malling stocks available, the limited supplies of M. VII and M. IV are probably more suitable for filler trees, where they are required, and to these we will return later, while trees on M. XII are definitely too strong growing and too slow to produce fruit for the bush plantation. M. XIII may be available from some nurseries, but this is not now recommended if better stocks are to be had. Of the seedling stocks that have been raised at the Long Ashton Research Station recently, we can say very little. The seed, which came from the canning factories of the Pacific North-West, from which triploid varieties are absent, was the best obtainable, and it is probable that these stocks will on the whole make vigorous trees ; but it is suggested that these stocks, which have been produced as a stop gap to help meet the prevailing shortage, be left for growers of standard trees, since two or three years in the nursery will enable the weaklings to be weeded out before they reach the plantation.

The two stocks M. I and M. II both generally produce fairly vigorous permanent trees, but on lighter soils, particularly for Cox, M. II is greatly to be preferred. Cox on M. I, except on strong growing moisture retentive soils, makes a poor tree which suffers readily from drought. On some of the poorer soils M. XVI may be preferred to M. II, because of its greater vigour and better root system, but one rather wonders whether growers who have experienced those soils in some of the recent droughty years would plant on them at all ?

Distance of Planting Permanent Trees.

Having decided on the varieties, the kind of tree and rootstock, the grower must now decide between two courses of action. Is it his intention to farm on the broad scale with trees wide apart,

farm operations mechanized, including possibly the use of a mobile spraying plant, and labour costs reduced to a minimum, or does he incline towards a more intensive planting system and consequent higher labour costs per acre? In making up his mind, the general size and economy of his farm, the cost and nature of his land and the necessity for a quick return on his capital must all play a part. He must also remember that in eight years' time Cox may be a much cheaper apple. It is now generally realized that, on average land, dessert apples on M. II will eventually fill a space of at least 20 ft. square and will probably need an even wider distance of planting on the fully mechanized farm. The distance usually recommended now for Cox on M. II is 24 ft. It has been suggested that, with mobile spraying, a rectangular plant, say 30 ft. by 20 ft., might be advisable, but the necessity for the machine always to move in the same direction, whatever the wind, would in the long run be a handicap rather than an advantage, and the square plant is thus to be preferred.

In a 24 ft. plant there are only 75 trees to the acre. While the reduced number of trees may be an initial advantage in these stringent times, if this is the plant adopted from the start without any form of interplanting, it does mean that the grower must be in a position to wait for his returns. It is true that, with plenty of space, the trees may be more readily subjected to the lighter pruning methods now generally advised and will consequently come into cropping earlier than in former days. Still, the trees have to be large enough to average, good years and bad, at least three bushels a tree (and that means six bushels a tree in a good year), before the yield per acre can approach that of more closely spaced plantations. The acreage yields must therefore be expected to be definitely lower until the trees are fully grown. To compensate for this, all costs must be kept to a minimum and, since this must involve full mechanization, it necessarily follows that the farm as a whole must be sufficiently large to bear the overhead costs, while the owner must be in a position to maintain himself until the plantations start to yield dividends.

It is not proposed to discuss the relative merits of fixed mains and mobile spraying for large-scale plantations such as this. For more intensive plantations, there is little question that, for the compact farm, fixed underground mains are the most economical. Before committing himself the grower must weigh up the relative merits of the two methods, remembering the possibility of very marked improvements by the time his plantation comes into bearing. The planting distance of permanent trees is likely to be the same whichever method is chosen, but, if interplanting is done, the mobile sprayer may run into difficulties and plans must be made accordingly.

Interplanting.

For the small fruitgrower and those who are just starting—and, if history repeats itself, there may be many such in the postwar years,—it may be vital to have some crop which will at any rate contribute something to the wages bill in the first few years, and for them some form of interplanting may be essential. However, before considering the possibilities, it should be emphasized that, whatever the interplant, the permanent trees are the most important in the plantation. They should be spaced at the distances they will eventually require and all operations on the interplanted crops subordinated to their welfare.

The first essential of an interplant is that it should crop quickly, and then make way for the permanent trees. The days of apple plantations interplanted with plums or pears have gone, probably for ever, and today the grower has the choice of interplanting with dwarf, quick cropping apples or a limited range of small fruits. In the light of experience the former seem greatly to be preferred, since their manurial and spraying treatments can be the same as those of the permanent trees. Two forms of bush tree are suitable, the *semi-dwarf*, which can be planted in the centre of the 24 ft. square (75 trees to the acre) and stay there without detriment for, say, up to 12 years, (see plan, Fig. 1), and the *dwarf* on M. IX rootstock, which can be interplanted at 12 ft. (225 to the acre) and stay up to ten years. Some growers may prefer a mixture of both, i.e. 75 semi-dwarfs in the centre of the squares and 150 dwarfs in the permanent tree rows. In such plantations the dwarfs come out first followed by the semi-dwarfs a year or so later. For semi-dwarf trees there are two rootstocks available, M. VII and M. IV. Both have minor disadvantages, which it is hoped will be absent in new rootstocks now on trial at East Malling, but both make excellent semi-dwarf trees, which, if pruned lightly, come into bearing early and crop heavily.

The treatment of *filler* trees on M. IX should be very different from that of similar trees grown as permanents. Their function is to crop early and, for that reason, they must not be hard pruned. This may entail weeping branches, which have to be tied up to keep them out of the way of cultivations and the normal growth of the permanent trees, but nothing elaborate is needed. Even staking, though desirable, may not be absolutely essential, for if a few blow over or break off it does not matter greatly in their short life. A dual purpose stake which can be used to support the branches may be recommended. The varieties interplanted may well be the same as those for the permanent trees in about the same proportions.

All the experience of interplanting apples with soft fruits in the last 30 years indicates that the procedure is wrong, at any rate as far as the apples are concerned. At a recent meeting, at which several horticultural advisory officers were present, the only bush fruit that they were prepared to approve for interplanting with apples was gooseberries. In the Ministry's Apple and Pear Bulletin*, strawberries are suggested as an intercrop during the first three years after planting. With two-year gooseberry bushes at £95 a 1,000, the present day (1945/6) price, this crop can only be of academic interest on anything but a very small scale. All other small fruits have obvious disadvantages because their requirements for spraying, manuring or cultivation are at variance with those of the apples. Nevertheless, to the smallholder and the new grower starting from scratch, the attraction of the quick returns from, say, a crop of black currants, may be irresistible, and, if he knows when to stop, does he harm the ultimate performance of the trees so very much thereby? At present we do not know. Perhaps when an experiment that is being planted in Kent in 1946 has been going for a few years, we shall be able to give the answer in pounds, shillings and pence.

For the present, it is for the grower himself to decide whether he can afford the large-scale method of farming, wherein his permanent trees get the best possible treatment from the start, or whether he must sacrifice something for a quicker return. Possibly, in the latter case, he would be better advised to devote only a part of his acreage to apples to start with and plant up the rest of his ground with black currants or some other soft fruit, changing over to apples when he can afford to do so. Whatever he does, he at least has the satisfaction of knowing that the kind of tree he wants can be provided for him—after this year, on certified rootstocks. Although there are still many questions about apple growing to which we do not know the answers, at least we now know something of our limitations. The grower of tomorrow will have the advantage of an ever-growing body of research workers, anxious to help solve his problems; the National Fruit trials will continue to test the new varieties, while there is now being built up a National Advisory Service stronger than ever before, whose aim it will be to ensure that all new knowledge is put across to him without delay.

Summary.

Considerations which should guide the dessert apple grower in planning new plantations are outlined. Varieties, kinds of tree, rootstocks and systems of planting, including the advantages and disadvantages of interplanting with quick cropping apples or small fruits, are discussed.

* Bulletin No. 133 of Ministry of Agriculture and Fisheries, published by His Majesty's Stationery Office. Price 2/6 net.

TWO NEW APPLE VARIETIES BRED AT EAST MALLING

By H. M. TYDEMAN

Tydeman's Early Worcester.

There has for long been a need to fill the gap that exists between the early dessert varieties, such as Beauty of Bath and Gladstone, and the later maturing Worcester Pearmain, and also to satisfy the demands of the market once Worcester is finished and before Cox appears. Though Worcester may have its faults, growers have found it to be a profitable market variety and so, when the task of raising new apples was taken in hand at East Malling, one of the aims was to breed varieties resembling Worcester Pearmain in appearance, but ripening at different times.

Of the numerous families raised for this purpose, the most promising proved to be a cross between McIntosh Red and Worcester, from which several seedlings were selected. These combined a similarity in fruit characters to Worcester with differing seasons of maturity. One of these, which ripened ten days to a fortnight before Worcester, seemed particularly suitable for helping to fill the gap at the end of August. (See *frontispiece*.) This seedling, raised in 1929, was first fruited in 1936 on M. IX stock, and subsequently on M. XII and on its own roots, in all cases making a thrifty and healthy tree that cropped freely. The fruits are similar to Worcester in shape and general appearance with a brilliant scarlet colour over a creamy ground. In flavour and texture they are generally considered superior, and were favourably commented on by two leading firms of Covent Garden salesmen to whom samples were sent. The flowers, which are smallish and pale like those of Worcester, are approximately midseason in time of opening and have always been out at about the same time as those of Cox's Orange and Worcester Pearmain. From preliminary tests Tydeman's Early Worcester appears to be a suitable pollinator for both these varieties.

To provide a quick and ample supply of fruit, a half standard tree of Lane's in full cropping was frameworked with this variety during the winter of 1939 and two bush trees, also Lane's, during the winter of 1940. About five bushels of fruit were obtained during 1943, a small quantity during the frost year, 1944, and well over twelve bushels in 1945. The fruits from these frameworked trees retained the characteristics of the original seedling and fruitgrowers, nurserymen and fruit salesmen to whom samples were sent, have been favourably impressed.

In the winter of 1942 it was sent to the National Fruit Trials and later on to a few selected growers in Kent, Sussex, Essex and Hereford, who were able to give it a critical trial. These growers agreed not to distribute graft material. In this way the potentialities of this new variety were widely tested and at the same time precautions taken to prevent its general distribution before there were good grounds for thinking that it was worthy of introduction. During the autumn of 1945, following an informal meeting of fruitgrowers and others interested, at which the fruiting trees were again critically examined and the merits of the variety thoroughly discussed, it was decided to introduce it under the name of " Tydeman's Early Worcester " and material for grafting has been distributed to between three and four hundred of the Station's members during the past winter.

Tydeman's Late Cox.

This apple has been arousing considerable interest among those growers who have inspected our experimental plantations of new apple varieties during the past two or three seasons. It was raised from a cross between Laxton's Superb and Cox's Orange Pippin in 1930 and first fruited, worked on M. IX, in 1937. It continued to crop well for several seasons and was considered so promising that it was top grafted on to a half standard tree of Lane's in 1940 and on to two bush trees a year later. These trees have made very large vigorous heads and, although they give the impression of still being a little juvenile and have not yet given heavy crops, several bushels of fruit were obtained in 1945.

The fruit is of a good medium size, round to roundish-oval in shape and is usually very even. On the tree the apples are of a light green colour generously flushed a deep brownish-red. As the fruits approach maturity, this changes to a bright rich crimson on a clear yellow ground with thin even russet markings. The fruits need to hang on the tree until very late if they are to store in the best condition, in fact last season they were left on the tree until some time after all the other varieties on the plot, including Laxton's Superb and Allington Pippin, had been cleared and then showed by a slight shrivelling in store that they had been picked a little too soon. The fruits have kept perfectly well in ordinary natural store until May, and it is of interest that one well known fruitgrower sent us fruits in the middle of June that he had kept in good condition in natural store. When ripe it acquires a rich flavour resembling that of Cox ; the flesh is yellowish, crisp and juicy.

With us, the trees have hitherto been somewhat too vigorous, due possibly to seedling vigour, and have made very large, rather dense heads, but they are now showing unmistakable signs of settling down. They make considerable lateral growth which, if left, spurs up and bears fruit along its length. The foliage is deep glossy green and has not so far proved susceptible to any form of spray injury. It appears to flower a little late.

When submitted to the Fruit and Vegetable Committee of the Royal Horticultural Society at their meeting on 19th February, 1946, it was unanimously recommended for inclusion in the National Fruit Trials. Several interested growers already have this variety on trial but its general distribution may be deferred for a short time.

Acknowledgement.

The writer's thanks are due to Dr. H. V. Taylor, author of *The Apples of England*, for assistance in obtaining the illustration of Tydeman's Early Worcester.

Summary.

A description is given of the new apple varieties, " Tydeman's Early Worcester " and " Tydeman's Late Cox ", with some details of the manner in which they were tested and selected.

DWARF PYRAMID CULTURE

By LESLIE R. E. MARTIN

THE past 15-20 years have seen the growth of Dwarf Pyramid Culture, a new intensive system of growing apples and pears which may eventually replace the old established method of cordon culture. The pyramid is especially suitable for gardens and has the advantage over the cordon that it is self-supporting, which means a saving of capital outlay in the provision of posts, wires and canes, and annual expense in retying the cordons to the canes. There may be a small saving in the number of trees per acre, but approximately 2,400 trees will be required, which is not much less than is usual for cordon growing nowadays. Whereas cordons planted as maidens are expected to crop in their second year, the pyramid is cut back to 20 in. in its first year and encouraged to produce wood growth as well as fruit buds.

Otherwise, the main objects are the same for dwarf pyramid culture as for cordons and all operations are directed towards producing high quality, easily accessible fruit.

Site and Soil.

The site should be as free from late spring frosts as possible, preferably with a gentle slope to north or south to allow of free air drainage between the rows of trees which should run N.-S. up and down the slope. Rows running across a slope may impede air drainage and should the rows run E.-W. the sides of the trees will be unevenly exposed to sunlight. Any soil suitable for other forms of apple and pear trees is suitable for pyramids, provided there are not too many stones which might make grassing down difficult. Before planting the ground should be deeply cultivated and cleaned from perennial weeds.

Rootstocks.

As for cordons, the very vigorous stocks M. XII, M. XVI and "Crab" are unsuitable, since they promote wood growth and delay cropping. M. II is the most popular rootstock for pyramids in this country, but M. IX and M. VII are also suitable, especially for the more vigorous varieties. If, however, M. IX is used the trees must be supported throughout their life. This can easily be done by a single strand of wire running down the length of the rows, about 3 ft. above ground level, to which each tree can be tied. M. IV has possibilities as a suitable rootstock owing to its semi-dwarfing qualities, but would also need supporting by a single wire to overcome its poor anchorage.

Planting.

Maiden (one-year-old trees) should be planted in order that the trees are well established before cropping begins. The trees should be 3 ft. apart in the row with a minimum distance of 6 ft. between the rows, the actual row space being arranged so that when the trees are fully grown there will still be enough space for a horse and cultivator to pass up the row, or for machinery to cut the grass in the centre of the rows. Where dwarf pyramids are grown as part of an ordinary fruit farm and it is necessary to use the large implements already existing, 8-9 ft. between the rows would be required. In planting, the trees should be set so that the graft union is about 3 in. above soil level.

Pollination.

A complete row of a pollinating variety is preferable to scattered trees, since any differential treatment is then more easily dealt with. A ratio of one row in four is recommended and careful reference should be made to "The Fertility Rules in Fruit Planting", Leaflet No. 4 of the John Innes Horticultural Institute, for varieties which are known to pollinate each other satisfactorily.

Pruning.

First Year.

After Planting. Maiden trees are pruned directly the buds begin to grow in the spring, cutting back to about 20 in. from the ground. If feathered maidens (one-year-old trees with side shoots) have been planted the shoots over 6 in. long are cut back to five good buds.

Summer. During the first summer the trees are allowed to grow unrestricted and no pruning is done.

Winter. The leading shoot is cut back, leaving about 9-10 in. of young wood, cutting to a bud pointing in the opposite direction to that of the bud at the first pruning. The aim must be to build up the central leader as straight as possible with radiating branches all the way up. Branch leaders are pruned back to 6-8 in., cutting to a downward or outward pointing bud.

Subsequent Years.

In the following years a variety of methods are open to the grower of dwarf pyramids, but the following method is very simple and gives good results.

Summer. In mid-July all the new laterals including branch leaders are pruned to 5 or 6 leaves. This process may have to be repeated about four weeks later.

Winter. The central leader is left until the winter, when it is cut back to 8-10 in. to a bud pointing in the opposite direction to that of the bud at the previous pruning. At this time, if there is much secondary growth, it should be cut back to the point of origin, also a few old or crowded shoots may have to be thinned out. Cropping is to be encouraged at the earliest moment, since fruiting will tend to restrict growth, but in the first few years any flowers on the main leader should be picked off before they have set so that the leader will produce side branches and not fruit.

Grassing Down.

When the trees are from 4-6 years old they may need checking to restrict growth, and this can be done by grassing down, using a mixture containing fine grasses and a high percentage of clovers such as :

	Per acre.
Rough or smooth stalked meadow grass ..	4 lb.
Perennial Rye Grass	6 lb.
Sheep's Fescue	2 lb.
Broad Red Clover	6 lb.
Wild White Clover	1 lb.

This mixture should be sown in early autumn or April. The grass, besides acting as a check to growth, greatly improves the quality of the fruit. The severity of the check to growth can be modified by the proportion of the ground that is grassed over, but usually it is sufficient to grass the centre 3 ft. or so of each space, keeping the actual tree rows free from grass and weeds by hoeing. If more check is required the whole area may be grassed down. The grass must be kept short and once it is established it may need cutting four or five times during the summer, the cut grass being allowed to fall and rot in position. This cutting may be done with a motor mower or autoscythe, or on a small scale with an ordinary lawn mower.

Manuring.

At planting time, provided the soil is in a good state of fertility and well cultivated, no manuring is necessary. Subsequently an annual dressing of meat and bone meal, about 6 cwt. per acre, should be given to maintain this fertility with, in addition, sulphate of potash, 2-3 cwt. per acre. Once a grass mixture has been sown more feeding is necessary. During the first year, if the trees appear to have received too great a check, a stimulant may have to be given in the form of sulphate of ammonia or its equivalent at 2-3 cwt. per acre. Superphosphate should not be omitted, but will not be necessary every year.

Spraying.

Normal routine sprays should be given to dwarf pyramids although in selecting the washes it may be desirable to choose the safer sprays, even if they are slightly less effective, and to rely on care in application and accurate timing to achieve efficient control. In the first few years the winter petroleum sprays against red spider and capsid may be omitted in order to avoid the bud damage sometimes caused by the spray.

Varieties and Thinning.

While most varieties can be grown as dwarf pyramids, the choice dessert varieties which will benefit from the extra care and attention are really the most suitable. Fruit thinning must be practised

in years of heavy cropping, thinning to allow approximately one or two fruits per cluster according to variety. To get the greatest effect this thinning should be done before the June drop, but may be carried on for a while afterwards.

Acknowledgements.

The work on Dwarf Pyramids at East Malling Research Station has been carried out chiefly by Miss A. B. Beakbane*, whose assistance in preparing this bulletin the writer acknowledges with gratitude.

Summary.

The Dwarf Pyramid system of growing apples and pears is briefly described, stressing the need for careful management at all stages of growth if success is to be achieved.

* Beakbane, A. B., and Martin, L. R. E. (1946). "The Intensive Culture of Hardy Fruit Trees. II. A Trial of Dwarf Pyramid Trees of Cox's Orange Pippin on Malling Rootstocks." (See page 45 of this Report.)

THE ROOTSTOCK MALLING CRAB C

By R. J. GARNER

THIS coming autumn the Research Station plans to distribute some 12,000 apple rootstocks known as Malling " Crab " C. Trees of a number of scion varieties have been grown to maturity on this rootstock at East Malling and have given an excellent account of themselves when planted alongside trees on other very vigorous rootstocks such as M. XII and the more popular M. XVI. For many years Crab C has been known to be a valuable addition to the limited class of very vigorous rootstocks, but hitherto it has proved comparatively difficult to propagate by the ordinary processes of stooling and layering and for this reason alone it has not been offered for wider use. We have now proved that it can be readily raised by means of root cuttings and also, to a lesser extent at present, by appropriately treated stem cuttings.

Origin and Selection.

Crab C came into our hands in the following way:

In 1912 a consignment of two-year-old seedlings of so-called " French Crab " rootstocks, obtained from a foreign source through an English nurseryman, was purchased and planted at Wye College in Kent. When set out they appeared to be very even. When inspected a year later these rootstocks were found to be mostly free growing and clean stemmed, only a very few were stunted and spined.

In February, 1914, the rootstocks were lifted and nine individual seedlings were selected to represent the wide range of variation and as showing signs of adventitious rooting and were planted at East Malling. Root cuttings collected from each and planted in boxes grew satisfactorily and were used to form stoolbeds in 1915.

In the winter of 1918-19 the specimens were lifted, inspected and photographed and five selections, lettered A., C., E., F. and H. were chosen for propagation and subsequent field trials. The stoolbeds were also examined at this time and notes taken of their rooting capabilities as under.

Selection A. Very few rooted layers, and these very poorly rooted.
C. Most layers rooted, but very poorly.
E. Layers well rooted.
F. Layers well rooted.
H. Few layers rooted and those poorly.

Except for the H., which was " very spreading and spiny—with dwarf scrubby habit—a type to itself ", all had made vigorous clean growth.

Attempts to root Crab C by the normal stooling method failed and layering, with and without etiolation, gave only mediocre results, the shoots developed roots but so sparsely that the rootstock could not be recommended to rootstock raisers. Nevertheless, when the layer bed was well established yields of first grade rootstocks occasionally equalled a production of 16,000 per acre. This figure must be compared with the normal yield of 35,000 from an equal area of M. XVI or M. II.

As rooted layers became available they were included in some of the rootstock trials at the Research Station. In 1919 Lane's Prince Albert was the chosen scion, in 1920 Grenadier, and in 1921 Lord Derby and in 1922 Allington Pippin and Newton Wonder. This last nursery provided the most complete set of trees and a description of this larger trial will serve to indicate the capabilities of Crab C in relation to the hitherto more readily available rootstocks.

Performance in the Plantation.

In order to test these selected " crab " rootstocks for half-standard trees the maidens from the 1922 buddings were run on for a second year and headed at 4 ft. 6 in. in the winter of 1923-4, and after a further season in the nursery they were set out in the field in December, 1924. After two years it became necessary to move the trees to another site at the Research Station and in March, 1927, when four years old, all the trees were transplanted. The total length of shoot growth per tree up to the end of the year of transplanting is shown in Diagram 1.

The initial vigour of standard trees is little indication of ultimate size of tree and cropping capability. Suffice to say that trees on Crab C behaved similarly to those on the popular M. XVI.

By 1934, their twelfth year, the trees of Newton Wonder had borne comparatively little fruit and in 1935 they were used for a grafting experiment and all grafted with Laxton's Superb. The

Allington Pippin had cropped rather better, the less vigorous rootstock M. I was leading at this time with a total crop of close on eight bushels. Crab C came next with seven-and-a-half, with M. XVI rather more than a bushel behind and M. XII totalling no more than five bushels.

At thirteen years of age, standard apple trees on very vigorous rootstocks are only at the beginning of their cropping history. To judge the suitability of such rootstocks for large trees it is essential to view their performance over a period of some twenty years or more. The trees were in their twenty-third year in 1945 and by this time the total crop weight showed Crab C well ahead of all others with little difference between M. XII and M. XVI. The cropping in relation to height and spread is shown

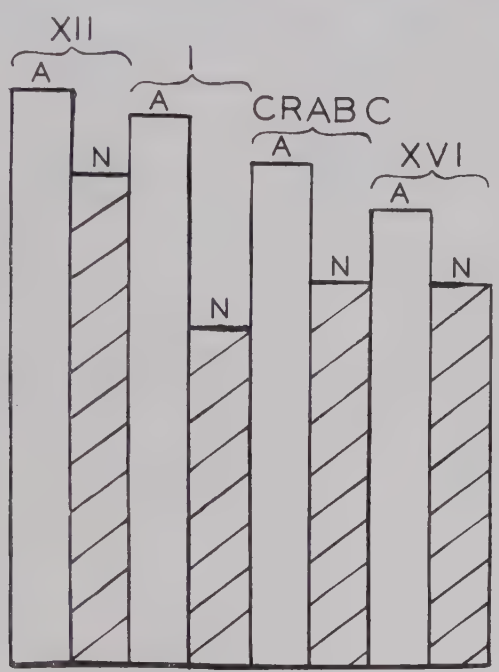


DIAGRAM 1.
Total shoot growth up to five years.
A = Allington Pippin. N = Newton Wonder.

in Diagram 2. It will be noted that though trees on Crab C are no larger, in fact somewhat smaller, than trees on either M. XII or M. XVI, they have borne heavier crops. The trees on M. XII have cropped less heavily than trees on Crab C though they are considerably larger.

Judging by the performance of trees of Allington Pippin on the available vigorous rootstocks it would seem that the rootstock Crab C is superior in cropping performance over a period of twenty-three years.

The cropping of other scion varieties on Crab C is also set out in Diagram 2 with the height and spread of the trees at the age given. Certain stocks are absent from these trials, so that the same comparisons as in the trial with Allington Pippin cannot always be made and the performance of Crab C must be compared with that of the rootstocks given. With Grenadier the cropping on Crab C has been heavier than on either M. I or M. XVI, and with Lord Derby better than on M. XIII or M. XV.

Lane's Prince Albert, as in other trials, performed exceptionally well on M. I and, though smaller, the trees have equalled the cropping of those on Crab C. The trees of this variety on M. XVI and Crab C, size for size, have behaved similarly whilst those on M. XII again fall short in spite of their larger size.

Performance in the Nursery.

As already stated, Crab C has never behaved satisfactorily in the layer bed. The growth is very vigorous but rooting quite meagre. Experimental plantings of shoot cuttings in the autumn have indicated that the basal parts of one year shoots will root and grow to the extent of about 10 per cent. of those planted. The remainder usually live on for a year and a proportion root and grow well in

the second year if left undisturbed. Treatment of shoot cuttings with growth substance has, in a few instances, increased the rooting of cuttings in the first season up to 35 per cent., but treated cuttings which failed to root in this first season did not survive until the next. The treatment given was to stand the cuttings, for twenty hours, with their bases in 30 parts β-indolyl butyric acid per

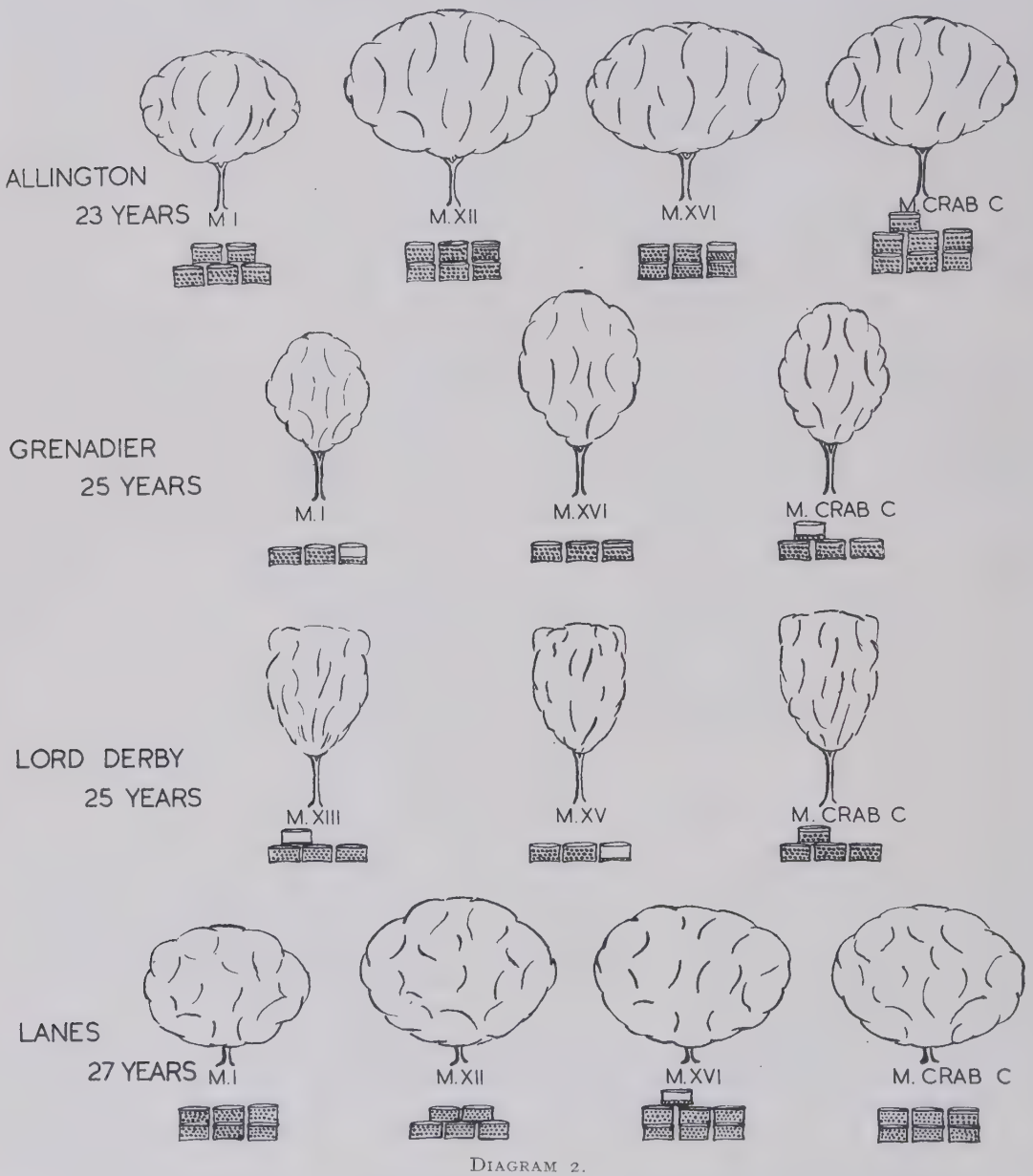


Diagram 2.

Size and total crop of four varieties worked on Malling Crab C and other vigorous rootstocks. Each full basket represents ten bushels.

million parts of water, immediately before planting. This treatment, though promising, is not yet recommended for commercial application. Numerous trials are now under way to test the effect of variations in methods of collecting, making, planting and chemical treatment and any results considered of value will be made available in due course. At present the surest method of propagating Crab C is by root cuttings collected from two- or three-year-old nursery material. These cuttings, about $4\frac{1}{2}$ in. long, may be any thickness from 4 to 20 mm. They are collected, as opportunity offers, during the winter, made, bundled in 25's, buried in soil in open ground and planted in March in soil.

preferably well aerated but moist. The cuttings are planted vertically 3 in. apart in rows spaced a foot or so for ease of cultivation. The top of the cuttings should not be buried more than an eighth of an inch for the best results. To ensure that the cuttings are set the right way up they are made with a slanting cut at the base. At East Malling some 70 per cent. of these root cuttings have established themselves in the first season and the majority have been fit to line out for working. Similar results are now being obtained by nurserymen who are testing our Crab C root cuttings in their nurseries.

Unlike some other rootstocks Crab C, once rooted, behaves excellently. Almost every cutting develops a single vigorous upright shoot with scarcely a lateral upon it. Crab C is excellent for building sturdy clean stems for high working. It is considerably less susceptible to Woolly Aphid than M. XVI. Like other very vigorous rootstocks it should be transplanted whilst completely dormant to avoid losses. It develops a sturdy root system containing both horizontal and vertical main roots.

Suitabilities.

Crab C should prove useful wherever vigour is required. On poor soils it should make a tree and where very large sturdy trees, on good trunks, are required on better soils, as in the West Country for cider apples, it should prove eminently suitable for the production of high worked trees.

Summary.

The origin and selection of the apple rootstock Malling " Crab C " are detailed. The vigour and cropping performance of four commercial scion varieties upon it, covering some 25 years, prove it has merits in advance of the commoner vigorous rootstocks. " Crab C " grows " cleanly " in the nursery but roots shyly in the layer bed. Root cuttings have proved a ready means of propagation and the method is described.

THE RECOGNITION OF SOME APPLE AND PLUM ROOTSTOCKS IN THE NURSERY

By R. J. GARNER

With photographs by ELEANOR C. THOMPSON

Now that the Ministry of Agriculture, after consultation with the nursery trade and representatives of the fruit industry, has undertaken the certification of the principal apple and plum rootstocks, it is opportune to offer the rootstock and tree raiser some practical means of recognizing his material. This brief article is intended as an aid to the recognition of the rootstocks which are listed in the Certification Scheme together with a few others that it is necessary to separate from those named in the scheme.

The means of recognition given here are in no way adequate for the trained botanist who wishes to distinguish each from all others. The botanist will find detailed descriptions elsewhere.* This method is based on the outstanding features of the rootstock in August and the captions under each photograph are concise descriptions of what the average practical man sees as he approaches the rootstocks growing in the nursery. In a few cases finer points are included to resolve doubtful identities.

The descriptions given must always be used as a whole and not broken up into their parts. For example both M. I (Broadleaved English) and M. IX (Jaune de Metz) each begin "Large . . . leaves . . ." and this factor of size cannot alone serve to distinguish these rootstocks. In the full description there can be no confusion.

The shoots photographed were all collected from stoolbeds and it may be argued that such vigorous growth is not always found on transplanted material. Rootstocks properly lined out for working should, however, grow equally as well as when stooled and are recognized from the features given. It is obviously essential to obtain good healthy growth of rootstocks in the nursery if for no other reason than to ensure their recognition, for only the very experienced can infallibly recognize poorly grown, closely bedded [transplanted] material with the rootstocks standing one in front of another.

The inspection and rogueing of established stoolbeds is helped by the fact that any material "out of character" will occur in clusters or groups which may be traced to a common mother plant, whereas transplanted rootstocks are often shuffled whilst planting. On the other hand, the older wood visible on the transplanted stocks serves to confirm diagnosis.

Nurserymen and fruit tree raisers who wish to have their rootstocks inspected with a view to certification under the Ministry's scheme should obtain details and form of application from the Secretary, Ministry of Agriculture, Government Buildings, Heyhouses Lane, Lytham St. Annes, Lancashire, not later than 1st June.

Summary.

Photographs and brief descriptions are given to aid the practical man to recognize the principal apple and plum rootstocks in the field.

* "Paradise Apple Stocks," by R. G. Hatton. *J. roy. hort. Soc.*, 1917, **42**, 301.
"Stocks for the Stone Fruits," by R. G. Hatton. *J. Pomol.*, 1921, **2**, 209-45.
"A Key to the Identification of Fruit Tree Rootstocks," by J. Floor, East Malling Research Station [unpublished].

M. XVI. KETZINER ISRAEL.

Growth very great. Leaves dull dark-green, except at growing tip where a light green in striking contrast. Lower leaves almost entire i.e. no saw edge. Older wood black.

M. II. (Doucin).

Stiff growth. Even-shaped leaves fairly close together. Very many conspicuous dots (lenticels) on the wood.

M. V. (Doucin Amélioré).

Leaf-tips drawn out to a point. Very few, but large dots on the wood; buds and leaf-stalks red when rubbed.

M. IV. (Holstein Doucin).

Thick leaves with rough surface and wavy edges: being close together give compact appearance. Wood light brown with fine cracks like old varnish. Lumps near buds common.

M. VII.

Whippy, clean growth. Thin, papery, somewhat shiny leaves. Leaf-stalks upright. Leaves circular when tip and stalk removed. Lower leaves sometimes lobed. Buds usually far apart.

M. XIII.

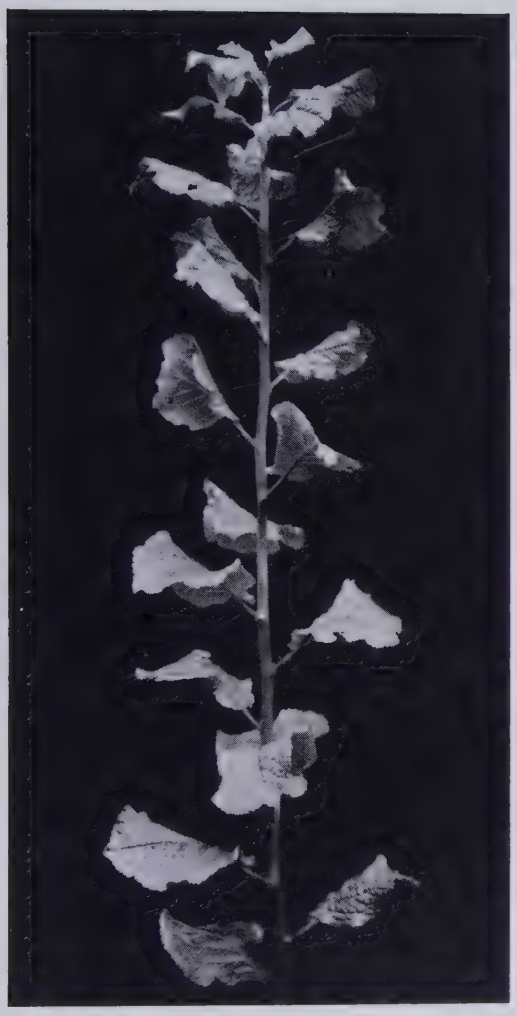
Leaves held erect. Deep cut leaf-edges, large leaflets at base of leaf-stalk and spiny shoots give a general ragged appearance. Older wood black-brown with prominent white dots (lenticels).

MALLING CRAB C.

Broad, dull leaves with " cross-cut " saw edges and large stipules. Leaves on upper part of shoot definitely upfolded. Shoots woolly throughout their length. Two year wood " burnt " red on the sunny side, never black-brown as in M. XIII. Very vigorous when layered.

M. XII.

Very stiff, erect, reddish-chocolate shoots bearing very shiny, upcupped leaves. Leaf-stalk kinked at base.



BROMPTON.

Fairly large leaves with rough surface, wavy edges and light green underneath. Leaves often much twisted as though attacked by a leaf-curling insect. Shoots dull, smooth and hairless.

BRUSSELS.

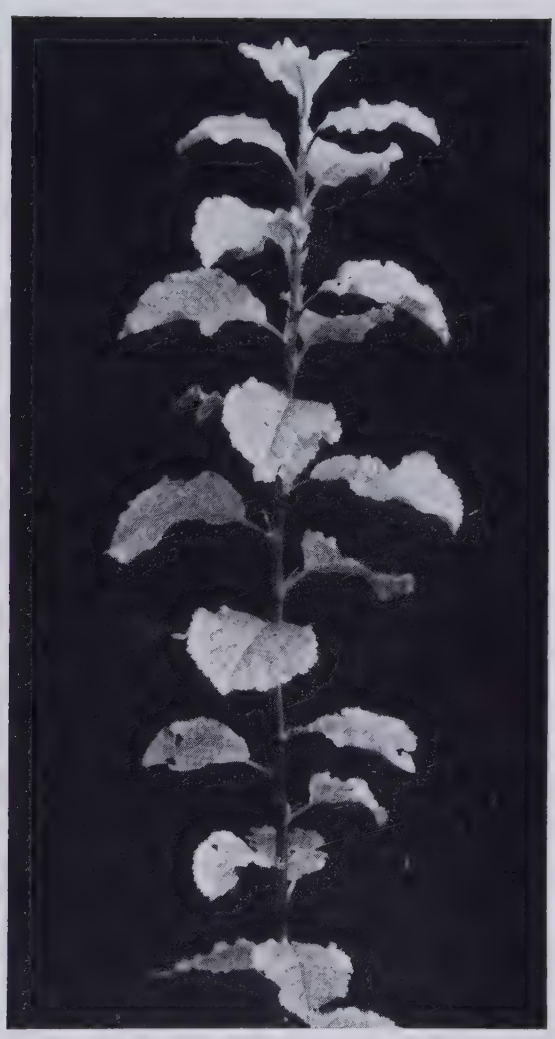
Large, smooth leaves down-cupped with pie-crust edges, dark green underneath. Shoots dull with short, grey hairs giving " bloom ".

MARIANNA

Slender reddish brown stems never erect. Very shiny, unfolded leaves practically completely hairless.

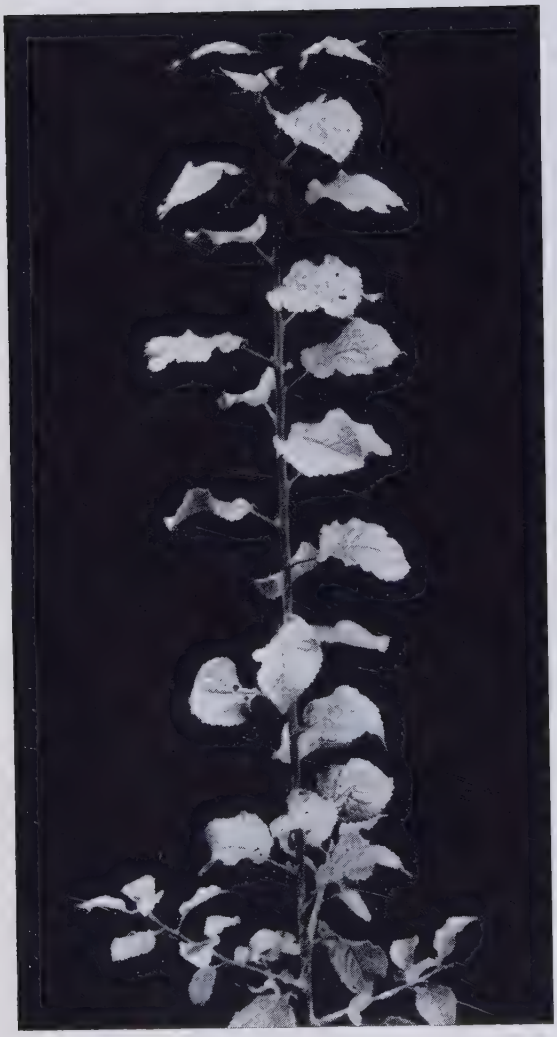
MALLING MYROBOLAN B.

Stems slender and bright green on shaded side. Leaves almost flat, slightly hairy on underside. Leaves almost always very torn and full of holes.



MALLING DAMAS C.

Dull, rough leaves on short stalks with very wavy, up-turned edges, giving ragged appearance. Dull, hairless stems with green patches. General appearance in bulk, yellowish—very slightly—pinkish green.



Common Mussel.

Leaves usually small and dark green with fine toothed edges. Stems often have laterals or spines. Leaf-stalk long in relation to size of leaf. Stems have short grey hairs giving " bloom ". Stipules on upper part of shoot stand upright and closely pressed to the stem.

Common Plum.

Leaf-stalk short in relation to size of leaf so that the leaves appear to be close to the stem. Stems light green on the shady side, smooth and hairless, often covered (peppered) with very fine specks. Stipules not closely pressed to the stem.

PLANT MYROBOLAN CUTTINGS CLOSER TO IMPROVE THEIR SHAPE

By R. J. GARNER and E. S. J. HATCHER

THE plum rootstock Myrobolan B is commercially propagated either by layering or by shoot cuttings taken and planted in the autumn.* In general, propagation by cuttings is preferred, but it suffers from a serious handicap not shared by the layering method. The rooted shoots from the layer bed are upright, need little trimming and are easily bundled, whilst the rootstocks raised from shoot cuttings habitually produce vigorous side branches which entail much work in trimming and are awkward to bundle. Moreover, this particular rootstock often becomes too coarse in the cutting bed. Any method of culture which improves the shape and restricts coarse growth is likely to be welcomed by the raiser of rootstocks.

The present method, on any but the smallest scale, is to set cuttings in rows spaced wide enough to allow horse or row-crop cultivation, the usual being 27 in. with a 2 in. spacing within the row. This inter-row spacing is relatively wide and it was considered that a much closer spacing might yield plants of better shape and fewer branches, more suited to the requirements of the nurseryman. Experiments were designed to test the effect of different planting distances and the detailed results will be published later. Meanwhile here is a brief report for growers to enable them to introduce the close spacing now to be recommended.

The effect of spacing on growth varies somewhat with local conditions of soil and seasonal variations in rainfall. The cuttings in these experiments were planted on two soils, the Malling loam and a lake-bed soil rich in humus, of close texture and naturally moist, and the experiments were done in the two seasons, 1942-3 and 1944-5, of contrasting weather conditions.

The first trial, in 1942-3, was on the two soils at the following inter-row spacings, 27 in., 18 in., 9 in. and $4\frac{1}{2}$ in. It was found that, as the distance narrowed, the number of shoots per cutting decreased. The number of side branches from the main shoots per cutting in Malling loam fell from eight at the widest distance to under two at the narrowest, while in the lake soil there was much more branching and less effect of spacing, the range being from twelve to eight side branches per cutting. The total length of these branches illustrate the spacing effect even more strikingly. In the lake soil their total length ranged from 80 in. at the widest spacing to under 50 in. at the closest ; in the loam soil, closing the distance between the rows to $4\frac{1}{2}$ in., reduced the branch length from 25 in. to as little as 4 in. The accompanying photograph shows typical plants grown at four planting distances on Malling loam. This illustrates, better than figures, the benefits gained by close spacing. The general uprightness of the plants tends to improve with close spacing whilst the proportion of rooted cuttings is not affected, stands of 60-80 per cent. being usual. Close spacing was thus highly effective on the loam, but had somewhat less influence on the lake soil, where considerably more branching resulted. However, since the lake bed is a highly specialized soil, practical recommendations must be based upon the results from the more normal loam soil.

Subsequent trials in 1944-5 confirmed the above results, though interesting seasonal contrasts in growth were observed. In 1943 the season was very early with heavy rain in May after a dry spring and the first, or main shoots from the cuttings, remained short and then branched vigorously, particularly on the lake soil. In 1945, a much more normal season, main shoots grew longer and bore fewer branches. The effect of spacing on branching was, however, quite definite in both years, as shown in the following table :

NUMBER OF BRANCHES ON EACH MAIN SHOOT

	Malling Loam.		Lake Soil.	
	1943.	1945.	1943.	1945.
Wide spacing 27 in.	2·78	2·34	4·78	3·79
Close spacing 9 in. in 1943 .. 6 in. in 1945 ..	1·33	1·30	3·68	3·09

* " Raising rootstocks." R. J. Garner. *Rep. East Malling Res. Sta. for 1942* (1943), 84-90.

The good effect of close planting on the shape of Myrobolan B rootstocks from cuttings is quite evident and the present wide planting of 2 ft. and more between the rows should now cease and much closer planting become the rule. To help decide upon suitable spacings other distances were also tested, namely 15 in., which is convenient for hand cultivation, and 6 in. for rows in beds. The results again clearly demonstrated the superiority of the closer spacing of a few inches, and the advisability of planting the cuttings in beds. A practical consequence of this is the necessity for hand cultivation from paths, thus limiting the length of the rows, and the width of the beds, to a maximum of 5 ft. As a guide in planting, two strings are set 5 ft. apart and rows of thirty cuttings are planted across the bed at 6 in. intervals. Spaces 15 in. wide are left between the beds for the workers to use when weeding.

Quite apart from the effect of spacing on branching of the main shoots there is a more general effect on size. On Malling loam and similar soils there is a likelihood, in most seasons, for cuttings at the 27 in. spacing to produce very coarse plants. Close spacing, as well as checking branching, prevents coarseness of growth and this is a further reason for recommending it to the rootstock raiser.

Summary.

Shoot cuttings of the plum rootstock Myrobolan B should be planted closely, in normal soil, to overcome excessive branching and coarse growth. Cuttings should be planted 2 in. apart in rows across 5 ft. beds at 6 in. intervals. Paths of 15 in. should be left between the beds.

PLANT MYROBOLAN CUTTINGS CLOSER TO IMPROVE THEIR SHAPE.
—BY R. J. GARNER AND E. S. J. HATCHER.

Photograph by Eleanor C. Thompson, East Malling Research Station.

One year rooted cuttings of Myrobolan B grown at different distances. Reading from left to right, 4½″, 9″, 18″, 27″. Note absence of branching in closer spacings.

[face p. 132

BACTERIAL CANKER AND LEAF SPOT OF PLUM AND CHERRY

A SUMMARY OF PRESENT KNOWLEDGE ON CONTROL MEASURES IN BRITAIN*

By M. H. MOORE

THIS disease was known as " Die-Back " for many years, and was responsible for widespread losses in plum and cherry trees, especially young ones. Its cause was not known, though each of two different fungi, *Cytospora leucostoma* and *Diaporthe perniciosa*, had been suspected by some workers because one or the other could usually be found on the dead bark. There was, however, no proof that either of them could kill healthy trees or branches. Adverse soil conditions were also suspected, but this idea did not fit the facts, for there were numerous cases of the rapid death of healthy trees growing in apparently ideal soil.

Dr. H. Wormald showed in 1928 that bacteria are the primary cause. Two closely related kinds are concerned in cherry, and he named them *Pseudomonas mors-prunorum* and *Ps. prunicola*, but only the first has so far been shown to cause this disease in plum, though the second is responsible for the wilting of young, green plum shoots.

The disease is therefore now known as Bacteriosis or Bacterial Canker and Leaf Spot of plum and cherry, and, as the name implies, it includes a phase on stem and branches (Canker) and one on foliage (Leaf Spot).

Plum.

The disease was rife at East Malling Research Station in two young plum plantations laid out as a variety and rootstock trial in 1921 and 1922. The soil was deep and well drained and the trees had grown well at the start. Trees of the varieties Victoria, Czar, and Giant Prune (Burbanks) suffered most, while those of President, Rivers' Early, Purple Egg, and Black Bullace seemed resistant. Giant Prune and Victoria are the most susceptible varieties also in the West Midlands ; Pond's Seedling is susceptible, but not so widely grown.

In 1931 Wormald published a review of the problem and a summary of seven years' observations on the disease in the Research Station plantations, including a detailed description of the symptoms. He showed that cankers—most commonly found in the stems—could be produced most readily from October to December (though they did not show up clearly till the following spring when stem thickening began) and that the presence of a wound was necessary for infection. They could not be produced during the summer months. The bacteria in existing cankers died out then, but were present in leaf spots—circular, dark areas that eventually fell out leaving " shot-holes ". He suggested that the disease might be controlled by :

(1) using resistant " stem-builders ", a method that had shown promise in America against Fireblight, a bacterial disease of pear trees ; (2) avoiding pruning, especially branch thinning during autumn and winter ; (3) protecting the foliage in summer and the stems in autumn by spraying with a bactericide.

Experiments were begun to test these possibilities, and the chief results are given below.

The use of resistant stem-builders.

The stem variety was budded on to rooted layers of the Myrobolan B rootstock in 1932. The 1933 growth from these buds was cut back at 5-6 ft., and in 1934 each stem was permitted to develop three branches. In March, 1935, Victoria grafts were inserted on to these branches each shortened to about 6 in. The stem and crotch was thus formed of the resistant stem-builder variety, the trees taking four years to raise from the original rootstock. Six commercial varieties, chosen because they had already shown varying degrees of resistance as scions, were used as stems—Warwickshire Drooper, President, Yellow Egg, Denniston's Superb, Utility, and Purple Egg. These were compared with the susceptible Victoria as a stem and with Myrobolan B, for, if this proved resistant, double-working could be avoided and a cheaper tree would result.

* Compiled from memoranda prepared for a meeting of the H.E.A. Fruit Committee on 15th January, 1946, by H. B. S. Montgomery and M. H. Moore, of East Malling Research Station, and H. E. Croxall and R. W. Marsh, of Long Ashton Research Station.

Four of these stem varieties—Myrobolan B, Warwickshire Drooper, President, and Utility—proved highly resistant. Purple Egg, resistant up to six years after planting, then developed many cankers. President, when top worked with Victoria, showed incompatibility with the Myrobolan B rootstock, though as a scion variety on this stock it had proved highly satisfactory.

Warwickshire Drooper roots well, and, though little experimental evidence is available of its performance as a rootstock, it might well prove valuable as a stem on its own roots. In Worcestershire it readily becomes established, grows vigorously, and on its own roots appears to be resistant. Myrobolan B is very promising commercially from this point of view, and is at present recommended. Utility, on the other hand, roots poorly and would thus be unsuitable.

Yellow Egg was relatively not very promising in this trial, but in the West Midlands it has been widely grown as a commercial though unprofitable scion variety. In being re-worked to the more profitable Victoria and Giant Prune, it has necessarily assumed the role of stem-builder, and while not resistant to Bacterial Canker, it has proved less susceptible than Giant Prune and Victoria, and has therefore served a useful purpose. Victoria top-worked on Yellow Egg was not very satisfactory as it produced a thin, straggling tree.

Comparison of times of pruning.

Two periods were compared (1) October, when infection could readily occur and (2) May, as near as practicable to the safe summer period. Normal pruning methods were used, and defeathering, done in the summer, was similar for both series.

Though there were differences in vigour, habit of growth, and crop as between the two series, there was no evidence that time of pruning affected the incidence of Canker. This was surprising, but the treatments had been applied to the branches and not to the stems, and, as plum branches appear to be infrequently attacked, they are perhaps the less susceptible. Large wounds, at any rate, should be avoided in autumn and winter, and branch thinning should thus be done in summer, as convenient. This policy also helps to prevent Silver Leaf infection.

Effects of spraying.

While the use of stem-builders offers hope for the establishment of new plantations, direct methods of control are needed for existing ones. Spraying trials were therefore super-imposed on the stem-builder trial to test the effect of stem spraying in autumn and foliage spraying in summer, but owing to the success of the stem-builder trial, few susceptible stems were available for assessing any effect of an autumn spraying.

During four consecutive seasons, there was no evidence that spraying with home-made Bordeaux mixture (10 : 15 : 100) in October significantly reduced the incidence of Canker. The trial then had to be abandoned as it was becoming impracticable to spray randomized individual trees and prevent drift. Arising from this work, a further trial was planned and is in progress to compare times of autumn application of Bordeaux mixture on susceptible Victoria stems, but insufficient cankers have as yet occurred on these trees to warrant conclusions.

Foliage sprays showed a marked reduction of Leaf Spot, but mere reduction of this phase may not be enough, for stem cankers were only slightly less numerous where Leaf Spot was diminished year after year than where it was not controlled. The importance of the part played by Leaf Spot in the annual cycle of the disease is still uncertain; complete elimination of this phase may be necessary to achieve satisfactory control of the canker phase on susceptible stems where an autumn spray is ineffective. A trial to test this possibility is in progress on low-worked Victorias, but so far no cankers have occurred on any of the trees, whether or not sprayed against Leaf Spot. Significant reduction in the number of *branch* cankers (i.e. on Victoria), which developed in the stem-builder trial in autumn 1941, followed the application of foliage sprays in the summer of that year.

As a result of comparisons of various times of application and strengths of sprays, it is at present recommended to spray susceptible plum trees with home-made Bordeaux mixture (4 : 6 : 100) about three weeks after petal-fall, and again two to three weeks later with a colloid copper preparation diluted to contain approximately 0·025 per cent. metallic copper. Bordeaux mixture is not recommended for the later application on cropping trees because it leaves a persistent visible deposit on the fruit. The inclusion of cotton-seed oil (0·75 per cent. v./v.) diminished the foliage damage that these copper sprays tend to cause in wet summers.

Other considerations.

The bacteria may perhaps overwinter in the buds, though this has not been proved by experiment. Pending further information, scion-wood must be regarded as a possible means of infecting the worked tree. An experiment by H. B. S. Montgomery in which healthy and diseased Victoria grafts

were compared has not proved conclusive, for the resulting trees have been virtually free from cankers up to the present, five years from planting out.

Preliminary work on the likely reasons for the occurrence of some varieties and the susceptibility of others has shown that trees of a resistant variety (Wyre Kidare Dropper) unlike those of a susceptible one (Laxton Prince), are in certain circumstances able to slow up the invading bacteria at an early stage by the formation of a barrier around the developing canker. The stem tissues of resistant varieties were less damaged by attack than those of susceptible ones.

Applications of inorganic fertilisers have had little or no effect on the resistance of the trees in the experiments so far undertaken, and there is little evidence of any such influence by the rootstock. Some observations by R. W. Marsh in the West showed that a higher proportion of low-worked Giant Prune trees died in the first seven years on Myrobolan than on Pershore or Kentish Bush, but he offered the information with reserve because it was derived from an experiment not designed to test this issue.

Cherry.

Wormald in 1937 published a full account of the symptoms which are similar in general to those on plum, though branch-infection and gumming are more frequent and Leaf Spot usually appears earlier in the season. Although, like those in plum, the bacteria present in cherry cankers usually die out in summer, they have been known to persist alive till August in some circumstances.

Among the more popular commercial varieties the following are especially susceptible: Napoleon, Florence, Schrecken, Ironsides, Ohio Beauty, Bradbourne Black, Emperor Francis. Early Rivers also has cankered severely in some districts, particularly after coming into bearing. Frogmore, Governor Wood, Elton, Nutberry Black, and Kentish are much less frequently attacked.

Some of the control measures mentioned under plum can be applied also to cherry, notably spring pruning, summer branch-thinning, and the careful selection of scion-wood. An experiment by Montgomery, similar to that on plum, in which scions of Bradbourne Black from healthy and diseased sources were compared as worked trees, showed no clear relationship between source of scions and the number of cankers recorded in 1945, eight years after the trees were worked. Nevertheless, while the possibility remains of introducing the disease on the scions, careful selection of them is an elementary precaution well worth the trouble. Dipping them before use in Bordeaux mixture is an added safeguard.

The use of stem-builders is promising for cherry as well as plum, for though the Mazzard (or Gaskin) stocks in general use vary considerably in susceptibility amongst themselves, they are on the whole more resistant than are susceptible scion varieties. Susceptible Napoleon trees worked high in the nursery survived the disease far better than similar trees worked low (i.e. those with a susceptible Napoleon stem), and high-worked trees on the layered Mazzard selection F 12/1 survived more uniformly than those on seedling Mazzards.

Spraying.

Although on plum there is so far no evidence that stem spraying in autumn controls canker on cherry it was very successful, and when coupled with a spring spray gave a programme that is now recommended. A spraying trial was carried out for four consecutive seasons on eight year old trees of the susceptible Bigarreau de Schrecken variety, severely attacked by the disease when they were taken over. Stem and branch spraying in autumn and protection of the opening buds by spraying in spring were tested separately and together.

At the end of four years a programme of two sprays each year had restored the trees to sound commercial condition. The first spray was applied about the middle of October, just before leaf fall, and the second just before the blossoms opened. Home-made Bordeaux mixture was used for each spray, at 10:15:100 in autumn and at 4:4:100 in spring. Either spray alone gave about half control, and there was evidence that spraying twice in spring (the second at 4:6:100 at Petal Fall) where an autumn spray was not given was an added advantage in certain seasons. During the four-year period, unsprayed control trees continued to canker fairly severely. Both the autumn and the spring sprays should be applied every year for most success, but it is unlikely that much result will be seen before the second year. As with plum, the inclusion of cotton-seed oil (0·75 per cent. v. v.) with Bordeaux mixture diminished spray damage to the leaves.

Laboratory tests have shown that the activity of Bordeaux mixture against these bacteria may be largely due to its alkalinity owing to the presence of lime. A new field trial is in progress on Schrecken to compare certain manufactured copper-containing sprays with home-made Bordeaux mixture, and opportunity has been taken to include a comparison of hydrated lime alone. Up to the present there have been insufficient cankers to warrant conclusions.

Influence of rootstock on scion susceptibility.

In the spraying trial described above, trees [illegible] on each of four vegetatively-propagated seedling Mazzard rootstocks (F 2/1, F 5/1, F 1/4, and F 12/1) showed greater susceptibility to the disease than similar trees on each of four others (F 2/2, F 1/2, F 5/3 and F 12/3). This was not a straightforward comparison, however, for the spraying trial had to be superimposed on the rootstock trial in the most uniform manner possible in the circumstances, and the comparison is therefore no more than an indication of stock influence. It will be noted that F 12/1, now being propagated in large numbers, is among those that tend to confer greater resistance in suckers; a similar tendency has been observed also in early leaves.

Experiments have shown that the rootstock can influence the incidence of spray damage in the scion variety.

Other Hosts.

Wormald has shown that the disease can attack several [illegible] purple-leaved plum (*Prunus Pissardii*), cherry plum (*Myrobalan*), morello cherry, and peach. These ornamental trees could thus act as a source of infection for plum and cherry, a possibility that could be of considerable importance in the nursery.

Summary.

The use of a resistant framework and foliage spraying with a copper-containing fungicide in summer at present offer most promise of controlling this disease in plum, and while transworking similarly holds promise for cherry, very good results were obtained by spraying with Lemonade Bordeaux mixture in autumn (at 10 : 15 : 100) and spring (at 5 : 5 : 100). Reference is made to varietal susceptibility and resistance to the influence of rootstock, and to experiments on the application of inorganic fertilizers. Other hosts subject to attack are mentioned.

GENERAL CONSIDERATIONS ON THE USE OF D.D.T. AGAINST FRUIT PESTS*

By H. SHAW

ALTHOUGH D.D.T. has only recently burst out upon the world, it has been known as a chemical substance for over 70 years. Its insecticidal properties were discovered in the laboratories of the Swiss firm of J. R. Geigy and Co. about 1937, and its first successful field application was for the control of Potato Colorado Beetle in 1939.

News of this discovery reached Britain slowly and in piecemeal fashion and it was not till the end of 1942 that the full possibilities began to be appreciated here. Under the wartime conditions then prevailing great efforts were concentrated upon adapting this new insecticide to use in the services, for the insecticide position was critical and had become a limiting factor in military operations, especially in tropical and sub-tropical climates. The story of the resulting triumph over body lice, mosquitoes, and other pests afflicting human beings is too well known to need repetition. The net result, however, was that all possible manufacturing sources were tapped for supplies for military purposes, and only small experimental quantities were available for the investigation of possible applications in agriculture. Nevertheless a great store of information has been accumulated during the past three seasons, though much remains still to be done.

The first reports of trials against plant pests were published by Wiesmann in Switzerland. Not all his results have been sustained in further investigations, but it was he who first indicated the possibility of controlling such pests as Carrot Fly, Winter Moth caterpillars, Apple Blossom Weevil, Codling Moth, and Raspberry Beetle by applications of Gesarol—a D.D.T. preparation.

These and similar tests of D.D.T. had not long been in progress before it was realized that the substance possesses truly remarkable properties not previously met with in pest control materials. Chief among these was the fact that alongside a contact poison activity that compares favourably with that of anything yet discovered, D.D.T. has a stability and persistence which confer upon it a protective action. And so came into being the new class of protective contact insecticides. Since D.D.T. is also a powerful stomach poison, this novel combination of properties opens up entirely new possibilities in pest control.

Against certain groups of insects D.D.T. has a phenomenal activity. Among those most readily affected are the flies and some of the caterpillars of moths and butterflies. It is claimed that under ideal experimental conditions a deposit amounting to no more than 1 oz. per 1,000 sq. miles is fatal to houseflies that alight upon it. On the other hand, the action is slow and several days may elapse before an affected insect dies. This may not, however, adversely affect control measures, for there is evidence that vital processes such as egg-laying may be interferred with long before death occurs.

So much has been made of the virtues of D.D.T. that it is now widely regarded as the final answer to every insect problem. This, however, is very far from being the case, and a recent estimate suggests that, against a wide variety of insect pests, it is better than the usual insecticides in less than half the cases. Its outstanding failure is against the Fruit Tree Red Spider, which appears to be quite unaffected by it. Results against aphides have been, in the main, unsatisfactory, but recent results suggest that there is room for considerable improvement in this direction when correct methods of formulation and application have been worked out.

The intense activity of D.D.T. has itself given rise to important problems. Outstanding among these is the possibility of serious damage to bees, but this, fortunately, has not so far materialized in practice. Although D.D.T. is toxic to bees, this insect is not among the most susceptible to its action and it seems necessary only to take similar precautions as would be taken in using lead arsenate, notably to avoid spraying open flowers. It has become increasingly evident in recent years that the control of many pests such as Red Spider, Woolly Aphid, and Cabbage Caterpillars is greatly assisted by the activities of predaceous and parasitic insects. It is now clear that many of these predators and parasites are very easily killed by D.D.T. and that adverse effects may follow the use of this insecticide. Experience has borne out this fear, for there has been a notable increase in Red Spider following the use of D.D.T. for Codling Moth control both in the United States and in Switzerland. There have also been reports of sharp increases in Woolly Aphid and Oriental Peach Moth.

D.D.T. has been found to be compatible with most other pest and disease control materials with the possible exception of nicotine under certain conditions. The nature of D.D.T. does, however,

* Adapted from a paper read at a Kent N.F.U. Fruitgrowers Conference, 14th February, 1946.

give rise to substantial problems of compounding and these are likely to be solved satisfactorily only in experienced hands. The types of preparation likely to be available include dusts, dispersible powders or pastes, solutions giving dispersions on dilution with water, preparations of the miscible oil or stock emulsion type, and solutions suitable for atomization. Each of these is likely to have its own particular sphere of application, and success in control measures may well depend upon selection of the correct type.

Because of the number of products on the market now that D.D.T. has been released, and because this material needs to be used with great discrimination and adequate knowledge, it is most desirable that its use should be controlled as far as is possible. It is hoped that this end will be achieved in a large measure by the approval of D.D.T. preparations under the official Scheme for the Approval of Proprietary Products for the Control of Plant Pests and Diseases.

All these facts indicate that the use of D.D.T. for the control of fruit pests in particular is a matter that demands very careful consideration. They do not, however, justify either of the extremes of approval or condemnation that have been freely expressed in the press. It is important to realize that the application of D.D.T. is still in the experimental phase and must remain so for a while. One of the most urgent needs is for a balanced, objective assessment, free from prejudices in one direction or the other, of its performance under commercial conditions. In short, we need still to learn how to use one of the most powerful weapons of pest control ever to be placed in our hands.

Summary.

A popular review of the possible application of D.D.T. in the control of fruit tree pests, with some discussion of its limitations and the precautions necessary in using it.

THE APPLE BLOSSOM WEEVIL AND ITS CONTROL

By G. H. L. DICKER

THE Apple Blossom Weevil ranks with Sucker and Caterpillar as one of our oldest apple pests, yet it is only recently, thanks to the introduction of new insecticides, that research entomologists have really felt they were mastering this pest. Sucker ceased to be a menace when tar oil was introduced, and regular spraying with petroleum or D.N.C. combined with lead arsenate in the lime-sulphur at the green cluster stage has eliminated Caterpillar from well sprayed orchards. Against weevil, until recently, a derris dust in April, followed by trapping with corrugated cardboard or sacking bands, was the best control that could be recommended. There is no doubt banding kept the weevil in check when practised regularly, but like derris it did not give consistently good results. Then D.D.T. and benzene hexachloride appeared, and from the moment the results of the first laboratory tests became available we felt this pest's days were numbered.

First a word about the habits of the weevil for these have a most important bearing on control measures. Since the spring of 1943 an intensive study of the life history has been undertaken at East Malling and through the collaboration of the Agricultural Research Council, the Pettar Society of Winter Wash Manufacturers and the Associated Fruit Growers of Essex, Ltd., facilities were kindly provided for similar studies and control experiments to be carried out in Essex by the staff of the Field Laboratory at Great Braxted.

Observations in both counties have shown that adult weevils come out of hibernation during March and early April. The numbers arriving from winter quarters are closely related to temperature ; with a daily maximum of less than 50° F. there is a very little weevil activity ; on warmer days, especially when the thermometer rises to 55° F. or above, many more arrive on the trees. Thus the spring population in the orchard is largely built up by the influx of weevils from neighbouring hedgerows, woods and fences on the warm days.

During the past three years a few days of real summer weather have always occurred about the time the buds were breaking, when this migration back to the trees reached its peak. Others continue to return even after the earlier arrivals are laying eggs. For a period the weevils are mainly concerned with feeding, after their long winter fast, by boring into fruit buds and excavating most of the contents. No serious injury results, but the effect can be noticed later in the form of occasional distorted blossom trusses with perhaps one or two sound buds and the remainder so damaged as to shrivel and fall before opening. Mating is the next preoccupation, often combined with feeding on the part of the female ; then follows egg laying which extends over a period of approximately three weeks.

The most important discovery during the recent observations has been the actual time of egg laying. This begins when the fruit buds reach the bud burst stage. For example, bud burst on the variety Lane's Prince Albert occurred at East Malling during the first few days of April in 1943 and 1944 ; the first eggs were found on this variety on 31st March, 1943, and 3rd April, 1944. Similarly, in Essex, Cox reached bud burst stage about 1st April, 1944, and eggs were first found two days later. 1945 was an early season with Lane's at East Malling and Cox at Danbury, Essex, showing bud burst in mid-March ; again eggs were first found at the same time, namely 17th March in Kent and 14th March in Essex.

Bud burst is the stage when the tips of the rosette leaves begin to protrude from the fruit bud, and is well illustrated in the Ministry of Agriculture's Fruit Tree Spraying Chart 1. In a normal season it occurs during the last week in March or first in April. That the onset of egg laying should be so closely related to a stage in bud development is another valuable point, for growers can now be advised to time their sprays according to the condition of the tree and not by dates, as so often happens, and sometimes leads to poor results due to our variable climate retarding or accelerating growth.

Eggs are laid singly in the young blossom buds. On hatching, the young grub starts feeding on the internal organs and by the pink bud stage, when fully grown, it has devoured everything except the petals. These are always nibbled at intervals around the base to prevent opening and they eventually turn brown to form the well-known capped blossom. The chrysalis stage is passed inside the blossom and, by early June, another generation of weevils is busy gnawing holes through the dead petals to reach the branches and feed on the undersides of the leaves. Three weeks later adults seek sheltered quarters in which they hibernate till the following spring.

Control measures have all centred around killing the adult before eggs are laid in the blossom buds. In timing a spray or dust it is necessary to bear in mind that weevils continue to arrive on the trees for at least a week after laying begins. There is a very good reason therefore to delay any measures until egg laying is judged imminent, for by so doing the population of weevils is greater and yet no material damage has occurred. Once laid the egg is so well protected that no spray will affect it. In laboratory tests a kill of 90 per cent. is regularly obtained when weevils are dusted with a 5 per cent. D.D.T. powder or placed on shoots dusted with the same material. Under similar conditions benzene hexachloride, of which the toxic constituent is commonly called " Gammexane ", gives a kill of approximately 60 per cent. with a 5 per cent. powder. Our field experiments have so far been confined to the use of dusts. *In all cases the first application was made at bud burst and subsequent ones at weekly intervals.* Results show that two applications of 5 per cent. D.D.T. give excellent control when used at 45-50 lb. per acre. In 1945 three applications of 5 per cent. D.D.T. at 70 lb. per acre reduced the percentage of capped blossoms by 99 per cent. and 84 per cent. respectively in Kent and Essex. In 1944 at East Malling by dusting twice with 5 per cent. D.D.T. at 45 lb. per acre, capped blossoms decreased by 96 per cent. whilst the same treatment with 3 per cent. D.D.T. gave a reduction of 65 per cent. in capped blossoms. Other trials with 3 per cent. D.D.T. in 1945 reduced capped blossoms by 80 per cent. when used twice at 70 lb. per acre, but had little effect at 45 lb. per acre. These figures demonstrate the efficiency of a 5 per cent. D.D.T. dust applied at 45 lb. per acre at bud burst and again a week later. The more variable results obtained with 3 per cent. D.D.T. indicate it is hardly strong enough to prove reliable.

Benzene hexachloride has not been tested so extensively. A 3 per cent. dust was included in the Kent and Essex trials in 1945 and two applications reduced capped blossoms by approximately 50 per cent. when used at either 45 or 70 lb. per acre. Although the 5 per cent. dust has still to be tested, there seems no reason why it should not be effective against weevil ; but from laboratory results the control is not anticipated to be quite as high as obtained with D.D.T. It is quite possible that by using rather more dust per acre its performance might be improved.

Reports of successful field experiments with D.D.T. in spray form have appeared in the weekly horticultural journals. All the results indicate that an effective control of the weevil is achieved *by spraying once at bud burst* with a concentration of 0·1 per cent. D.D.T. For convenience and to avoid any mathematical miscalculations, growers are advised to dilute according to the manufacturer's instructions. This spray needs to go on about a fortnight before the routine lime-sulphur at the green cluster stage and will normally mean an addition to the spray programme. If desired, lime-sulphur can be safely mixed with D.D.T., but it is inadvisable from the point of view of controlling scab to add lime-sulphur to the bud burst weevil spray at the expense of omitting one of the normal pre-blossom scab sprays.

So much for the investigations to date, much more needs be done. For example the effect of only one application of dust has still to be assessed and the concentration of D.D.T. in the bud burst spray might be reduced as the result of further trials. Benzene hexachloride has to be tested in spray form, and the possibilities of incorporating D.D.T. and benzene hexachloride in D.N.C. or petroleum in order to save an additional spray are also being investigated.

Lastly a word of warning. One of the most valuable properties of D.D.T. is its ability to persist in toxic form for longer periods than any of the previous known contact insecticides. This is a great advantage from the point of view of killing pests as it may mean a reduction in the number of applications necessary. But D.D.T. does not discriminate between friends and foes, and its effect on beneficial insects such as predators like lady-birds, hoverflies, lacewings and certain capsids, parasites and bees is being studied. The sprays or dusts used for Apple Blossom Weevil control are unlikely to have any material effect on these insects if applied at the correct time, for at bud burst very few of them are about on the trees, and the deposit has lost its toxicity before many arrive.

Summary.

The life history and control of the Apple Blossom Weevil are described and the following two recommendations for the control of this pest are made. Both seem equally effective and choice depends largely on equipment and labour available :

1. Dust with 5 per cent. D.D.T. at bud burst and again a week later, using about 45-50 lb. per acre each time or,
2. Spray with 0·1 per cent. D.D.T. wash at bud burst.

OVERWINTERING OF THE WOOLLY APHID PARASITE (*Aphelinus mali* Hald.) IN LOW TEMPERATURE APPLE STORES

By A. M. MASSEE

THE introduction of the parasite (*Aphelinus mali* Hald.) to control the Woolly Aphid is not quite so simple as it might at first appear. Weather conditions and other causes may check the breeding of the parasites, and then only a partial control will be obtained. On the other hand, when conditions are favourable, the parasite may succeed in reducing the Woolly Aphid population to a minimum. The parasite then migrates elsewhere or dies out, and the aphid population builds up again, so that in three or four years, or even sooner, the trees may become heavily infested once more.

Furthermore, although the parasite can withstand quite low temperatures without any serious mortality, the damp, wet conditions of the English climate are not suited to its survival (1) and in some seasons the overwintering forms may perish. This is probably the reason why the parasite failed to establish itself under natural conditions in this country during the early years of its liberation in commercial orchards.

It is essential, therefore, to find a method of keeping a supply of the parasite available from season to season, so that it can be reintroduced into any orchard that has become infested with Woolly Aphides, and in the autumn of 1943 experiments were started on the overwintering of the parasite in cold storage and dry storage conditions.

Experiments in Kent.

On 18th October, 1943, twelve hundred shoots of Cox's Orange Pippin bearing suitable colonies of parasitized aphides were collected in Kiln Field, East Malling, where the parasite had been observed in quantity during the summer. These shoots were taken to the laboratory and carefully examined, all predaceous insects, such as syrphid larvae and ladybirds, being removed. They were then laid out singly in four apple trays which were each wrapped up in a sheet of stout paper as a protection. On 20th October three of the trays, containing a total of 900 shoots, were put in an experimental cold storage chamber at the Ditton Laboratory, East Malling, at a constant temperature of 45° F. The fourth tray, containing 300 shoots, was put under dry storage conditions in a boarded loft at the Research Station.

Examinations made on three occasions during the winter months showed that the parasites in cold storage were alive and apparently healthy and that no hatching was occuring. On 19th May, 1944, the trays were taken from the store and the shoots were lightly damped with an atomizer containing tap water at room temperature and on 1st June the parasites began to emerge, the greatest number hatching on 8th June. The newly emerged parasites and the shoots were returned to an infested orchard and readily attacked the colonies of aphides, becoming firmly established during the summer and greatly reducing the Woolly Aphid population by the end of September (2).

No parasites emerged from the shoots kept in dry storage, taken to the laboratory at the same time, and treated in the same way as those from cold storage and subsequent experiments confirm that this method of overwintering the parasite is not successful.

A commercial grower carried out a similar experiment in October, 1943, putting shoots bearing parasitized aphides from his orchard at Brenchley into a commercial apple store at a temperature of 39° F. At the end of May the shoots were taken from the store and put in the orchard, where the parasites successfully emerged in June.

Experiments in Essex.

In mid-October, 1944, a similar experiment was conducted in a commercial gas store adjoining the Entomological Field Laboratory, Porter's Farm, Great Braxted, Essex, with twelve hundred shoots collected from an orchard at Little Baddow, Essex, and laid out singly in apple boxes. The temperature of the store was controlled at 39° F., except for a few days in the coldest part of the winter, when no temperature control was maintained. During the storage period, examinations at fortnightly intervals showed that both the parasitized and unparasitized aphides were alive.

During the first week of June the shoots were taken from store and the majority were distributed to growers in Essex and Kent, where the parasites emerged successfully and established themselves.

The rest of the shoots were kept under observation at the Field Laboratory where large numbers of parasites were seen to emerge during the second week in June.

Discussion.

The fact that it is now a commercial proposition to overwinter the Woolly Aphid parasite in cold or gas storage and liberate the emerging adults the following spring materially lessens the problem of Woolly Aphid control.

The cost of housing the parasites during the winter is small, since they can be kept in the chamber along with the apples, the amount of space occupied being small. The cold store would, of course, have to be kept running in the spring after the apples have been removed, since it appears necessary to keep the parasites in cold storage until the end of May. If the parasites are removed earlier, in say March or April, they would emerge and probably perish before the aphides in the orchards were plentiful enough to support them.

In practice growers should co-operate by passing the parasite from one fruit farm to another and the grower with storage facilities may do his neighbours a good turn by overwintering the parasite, even if he has no Woolly Aphid problem on his own farm. A fruitgrower in Essex did this during the winter 1944-5 and the success he obtained justified the work involved.

The following points should help those who wish to try this method.

The parasites overwinter inside the parasitized aphides. These can be recognized as they have much less flocculent white wool, and their bodies are black and smaller than the normal aphid.

Shoots bearing such parasitized aphides should be collected in October on a dry day ; mould soon develops if they are put into store while damp. The shoots must be laid out in a single layer in suitable boxes and on no account must they be put in a heap in the boxes.

A constant temperature between 39° and 46° F. must be maintained until May, when the shoots can be taken out.

In the orchard a bunch of ten or twelve shoots should be tied to a tree bearing a bad infestation of Woolly Aphid colonies. The parasite may fail if only a few individuals are liberated in an orchard. Some growers allow Woolly Aphid colonies to develop on the rootstock suckers that frequently grow around the base of tree trunks and these colonies, especially those that develop just below ground level, may assist the parasite to become established by providing it with a suitable source of Woolly Aphides.

Acknowledgements.

The writer expresses his best thanks to Dr. C. West, Superintendent, Ditton Laboratory, East Malling, and to Mr. G. Y. M. Sketch, Porter's Farm, Great Braxted, Essex, for cold storage facilities provided in Kent and Essex respectively. To Lieut.-Colonel T. H. Gloster for providing the Woolly Aphid parasite material from his orchard at Little Baddow, Essex. Also to Mr. M. D. Austin for his help and interest in the Essex experiments.

Summary.

An account is given of experiments in the overwintering of the Woolly Aphid parasite (*Aphelinus mali* Hald.) at low temperature in commercial apple storage chambers. Temperatures of 46° F. and 39° F. proved satisfactory. Practical instructions are given for collecting the shoots bearing parasitized aphides in the autumn, storing them and liberating the parasites in the spring.

References.

(1) Stenton, R. (1925). " Introduction of a Parasite of the Woolly Aphis." *J. Minist. Agr.*, 32, 343-9.

(2) Massee, A. M. (1944). *Rep. E. Malling Res. Sta. for 1943*, 65-7.

INDEX

Abnormal lignification, 18, 23
Abscission process, 27
Acaricides, 39
Acid cherry rootstocks, 17
—— . —— varieties, 20
Alpha-naphthaleneacetic acid, use of, on apples, 27
Amateur's Demonstration Fruit Garden, 18
Anatomical studies, 18
Angle of planting apple cordons, 23
Apple Blossom Weevil, 36, 38, 39
——— ——— ——— control, 36, 39, 138, 140
——— breeding, 20, 63
——— Brown Rot diseases, 32
——— Canker, 32
——— Capsid Bug control, 36, 40
——— Codling Moth, 38, 94
——— ——— ——— control, 15, 39, 138
——— cracking, 75
——— Fruit Rhynchitis, 90
——— ——— thinning trial, 19
——— late flowering varieties, 20, 65
——— Leaf Scorch, 18, 22, 30
——— mineral content of leaves, 30, 31
——— pollination in dessert apple plantations, 117
——— pruning of cordons, 23
——— ——— dwarf pyramids, 45, 123
——— root cuttings, 18, 128
——— rootstock, Crab C, 18, 126
——— rootstocks, 13, 17, 18, 23, 27, 31, 34, 63, 126
——— ———, anatomy of, 18
——— ———, breeding, 63
——— ———, experiment on the control of Crown Gall, 34
——— ——— for dessert varieties, 118
——— ——— dwarf pyramids, 47, 123
——— ——— immune from Woolly Aphid, 17, 63
——— ———, in relation to mineral composition, 31
——— ———, new varieties, 13, 17, 63
——— ———, propagation, 18, 126
——— ———, recognition in the nursery, 130
——— Sawfly, 15
——— ———, control, 39
——— Scab, 15, 32
——— ———, control by phenyl mercury chloride, 32, 40
——— ———, ——— mercurated lead arsenate, 34, 40
——— ———, ——— sulphur sprays, 15
——— ———, methods of measuring infection, 32
——— seedlings, 20, 65
———, sprays to prevent pre-harvest drop, 27
———, Twig Cutter, 90
———, Tydeman's Early Worcester, 121
———, Tydeman's Late Cox, 121
——— varieties, breeding, 64
———, Woolly Aphid, parasite of, 36, 142
Apples, acreage and cropping, 11
———, Black rot caused by *Monilia cinerea*, 34
———, breeding experiments, 20, 63
———, control of Brown Rot, 32, 34
———, commercial dessert varieties, 115
———, cordon culture, 18, 23
———, dessert, planning new plantations, 115
——— dwarf pyramid culture, 19, 45, 123
———, intensive culture, 18, 23, 45, 123
———, interplanting in commercial plantations, 119
———, new cultural trials, 17
———, new varieties, 121
———, system of planting, 118
Apricot, variety collection, 20
Arboretum of rootstock varieties, 20
Auxins, 28

Bacterial canker, control of, 34, 135, 136
——— ——— of plum and cherry, 32, 134
——— ———, other hosts, 137
——— ———, resistance of plum trees to, 34, 134
Benzene hexachloride (Gammexane) as an insecticide, 36, 91, 95, 140
Biennial bearing, 19
Black Apple Rot, 34
Black Currant Leaf Curling Midge, 38
——— ——— Reversion, 33
Black Currants, cultural and manurial trials, 21
——— ———, propagation, 13
——— ———, pruning trial, 21
——— ———, seedlings, 21
Bordeaux mixture for control of Bacterial Canker, 15, 34, 135, 136
Boron deficiency, 29, 84
Bradbourne, lake bed, 49, 79, 131
———, walled gardens, 19, 22
Breeding, tree-fruits, 20, 63
———, small fruits, 21
Brown Rot diseases of apple and nut, 32
——— ——, of apples, control in commercial orchards, 34
——— —— disease causing Nut Drop, control by spraying, 32

Cane nurseries, for raspberries, 23, 33
Cereals, acreage and cropping, 14
———, experiments for control of mineral deficiency, 29, 83
———, seed soaking for nutrient supply, 85
Cherries, cropping, 12
———, double-working, 18
———, mineral deficiencies, 29
———, varieties and classification, 20
Cherry Bacterial Canker, 32, 136
——— ——— ———, control by spraying, 15, 34, 136
——— orchard planning, 22
——— rootstocks, 17
——— ———, in relation to Bacterial Canker, 137
——— varieties resistant to Bacterial Canker, 136
Chlorophenols as ovicides, 39
Clay Coloured Weevil, 92
Cockchafer, 92
Codling Moth, 38, 94
——— ———, control, 15, 39, 138
Colour of fruit, estimation by sampling, 25
Combined sprays for cure of deficiencies, 84
Compatibility of rootstock and scion, 18
Copper deficiency, 84
Cordon culture of apples, 18, 23
Cover cropping, 18
——— ———, short-term leys, 22
Cover crops, spray damage on, 19
——— ——, top: root ratio, 22
Crab C apple rootstock, 18, 126
Crab Leaf Miner, 94
Cracking of young apples, 21, 75
Crop recording, 25, 26
Crown Gall, 34, 35
Curative experiments for mineral deficiencies, 29, 30, 83
Currant aphids, 37

Cuttings, hardwood, 18, 27, 49, 79
——— ———, distance of planting, 131
———, layer, 105
———, root, 18, 128
———, runner, 104
———, soft-wood, 41, 96

D.D.T. as an insecticide, 91, 93, 95, 138, 140
——— effect on beneficial insects, 36, 138, 141
——— field trials, 36, 40
——— laboratory tests, 39
Deficiencies, boron, 29, 84
———, copper, 29, 84
———, iron, 29, 84
———, magnesium, 30
———, manganese, 29, 83
———, multiple, 29, 84
———, nickel, 29, 84
———, potassium, 30
———, symptomless, 84
———, zinc, 29, 84
Dessert apples, plantation planning, 115
Devon, The red soils, 84
Diagnosis of deficiencies, 84
Dithiocarbamates as fungicides, 39
D.N.C.-petroleum wash as ovicide, 15, 40
——— ——— ———, damage to "renewal" pruned apple trees, 19
Double-working pear and quince, 17
——— sweet cherries, 18
Dwarf disease of loganberries, 33
——— pyramid culture, 19, 45, 123

"Established spur" system of pruning, 19
Experimental design, 25
——— gassing machine, 37
——— nurseries, 13
——— orchards, 11
External contacts, 44
Feathered Thorn, 93
Fertilizers, inorganic, 19
Field experimental design, 25
Flat-celled Shot Borer, 92
Frameworking on stems resistant to Bacterial Canker, 134
Frost damage investigations, 19
——— ——— prevention, 21
——— ———, to walnuts, 71
Frost-resistant varieties, 20, 65
Fruit Bark Beetle, 91
Fruit drop, pre-harvest, 27, 28
Fruit gardens, for amateurs, 18
Fungicides, field trials, 40
———, laboratory tests, 39
———, ——— ———, technique, 39

Gall mites, 38
Gammexane (benzene hexachloride), 141
Gassing machine, for nicotine vaporizing, 37
Gooseberry aphids, 37
Ground Beetle, eating stored apples, 38, 90
Growth substance, spray to control pre-harvest fruit drop, 27
——— ———, treatment of apple rootstock cuttings, 18, 27, 128
——— ———, ——— hop cuttings, 41, 96
——— substances, on plum rootstock layer beds, 22
Gesarol, 39, 138

Hemiptera-Heteroptera, distribution in Britain, 38
Histological Investigations, 18

Hop Aphis, 14
—— diseases in Great Britain, 35
—— Downy Mildew, 14
—— growing in Great Britain, 42
—— Eelworm, 42
—— Layer cuttings, 105
—— Mosaic, 42
—— Mould, 14, 15, 41, 107
—— Nettlehead, 42
—— parentage in relation to mould incidence, 109
—— Red Spider, 38, 42
—— runner cuttings, 104
—— Verticillium Wilt, 41
—— ——— ——, varieties resistant to, 41, 42, 101
—— virus diseases, 42
Hops, acreage and cropping, 14
——, brewing tests, 41, 43
——, cropping in relation to mould incidence, 112
——, commercial varieties, 41
——, comparison of strap cuts, layers and natural runners, 104
——, cultural trials, 41, 42
——, layering, 41, 104
——, lightning damage, 42
——, Ministry Certification Scheme, 42
——, new varieties, 14, 41, 43
——, —— ———, incidence of mould, 111
——, propagation trials, 41, 96, 104
——, preservative value, (P.V.), 25, 41
——, pulling, 42
——, soft-wood cuttings, 41, 96
——, ——— ——— treatment with growth substance, 41, 96
——, strap cuts, 104
Hormones, 27
Hormone relations, 28
Hybrid berries, 20

Identification key, for strawberries, 20, 23
Inarching, 18
Incompatibility, of pear on quince, 18
Injection, for diagnosis and cure of mineral deficiencies, 29, 30, 86
Inorganic fertilizers, 19
Insecticides, 36, 39
Intensive culture of apples and pears, 18, 23, 45, 123
Interplanting in dessert apple plantations, 119
Iron deficiency, 84
Irrigation, 19, 21

June drop, 27

Lacewing Fly, 95
Late-blossoming varieties, 20, 65
Layers, treatment with growth substances, 22
Layering of hops, 41, 104
Lead arsenate, 15
Leader-tipping, effect on pears, 54
Leaf Curl disease of raspberries, 33
—— painting, for diagnosis of deficiencies, 30
—— scorch, 18, 22, 30, 86
—— weevil, 92
Lightning damage to hops, 42
Lime-sulphur, 15, 40
Little Longicorn Beetle, 90
Loganberries, 12, 20
———, cultural trial with, 21
———, propagation of, 14
Loganberry Cane Spot, 32
——— Dwarf disease, 33
Lognormal distributions, 26
Lonchocarpus, 40

Magnesium deficiency, 30
Malling Promise raspberry, 133

Manganese deficiency, 29, 30, 83
———— ————, spraying for control of, 29, 83
———— physiological effects of, 89
Mangolds, field trials to control deficiencies, 30
Marshlands of Kent, 83
Marsh Spot disease of peas, 85
Medlar Cluster-Cup Rust, 34
Mercurated lead arsenate, for apple scab control, 34
Meteorological observations during 1945, 77
Meteorology, 21
Migration of Fruit Tree Red Spider, 36
Mineral deficiencies, 22, 29, 30, 31, 83
Mosaic disease of hops, 42
—— ——— of raspberries, 33
Mould of hops, 14, 15, 41, 107
Multiple deficiencies, 29, 30, 84

Nettlehead, virus disease of hops, 42
Nickel deficiency, 84
Nicotine, as insecticide, 15
————, vaporized, against Strawberry Aphid, 37
Nitrophenols as ovicides and acaricides, 39
Nut Drop of cobnuts, 32

Organic bases as ovicides, 39
Organic mercurials as fungicides, 32, 40
Ovicides, laboratory tests, 39

Parasite of Woolly Aphid, 36, 142
Peach varieties, 19
Peaches, rootstocks for, 17
Pear pruning, 54
—— rootstocks, 18
—— ————, new varieties, 63
—— varieties, breeding, 65
—— ————, in pruning trial, 55
—— seedlings, 20, 65
Pears, acreage and cropping, 12
——, double-working, 17
——, intensive culture, 18, 23
——, rootstocks for, 18, 63
Peas, acreage and cropping, 14
Phenyl mercury chloride for Apple Scab control, 40
Physiological effects of manganese, 29, 89
Plant analysis methods, 29
—— injection for cure of deficiencies, 29, 30
—— ———— for diagnosis of deficiencies, 30, 86
Planting distance, effect on cordon apples, 23
——— ————, for dessert apples, 118
——— ————, for Myrobolan cuttings, 131
Plantings in 1945, 13
Plum Bacterial canker, 32, 34, 134
—— rootstock cuttings, distance of planting, 131
—— ——— ————, effect of soil, 49, 79
—— rootstocks, 17
—— ————, new varieties, 64
—— ————, propagation from hard-wood cuttings, 49, 79, 131
—— ————, recognition in the nursery, 130
—— ————, treatment of layers with growth substances, 22
—— Sawfly, 95
Plums, cropping, 12
Pollination in dessert apple plantations, 117
———— of walnuts, 72
Potassium deficiency, 19, 30
Potatoes, acreage and cropping, 14
———, field trials to control mineral deficiencies, 29
Predaceous insects of Fruit Tree Red Spider, 36
——— ————, effect of D.D.T. on 138
Pre-harvest fruit drop, spraying for, 27, 28
Propagation of hops, 41, 96, 104
———— rootstocks, 13, 18, 49, 79, 127, 131
———— soft fruits, 13, 21

Pruning, 19, 23, 45, 54
———, in relation to Bacterial Canker, 135
———, ———— biennial bearing, 19
———, of dwarf pyramid apples, 45, 123
———, summer, on cordon apples, 23
———, winter, on pears, 54

Quince rootstocks for pears, 17, 18, 63

Raspberries, breeding, 21
————, propagation, 14, 21, 33
————, seedlings, 20
————, varieties, 20, 133
Raspberry Beetle, control by D.D.T., 39, 40, 138
———— Cane Blight, 12, 20, 32
———— —— Midge, 20, 32, 37
———— —— Nurseries, 21, 33
———— —— ————, planting and maintenance, 23
———— —— Spot, 32, 33
———— diseases investigations in Scotland, 33
————, insect vectors of virus diseases, 33, 37
———— Leaf Curl, 33
————, Malling Promise, 133
———— Mosaic, 33, 37
———— Moth, 33
———— virus diseases, 32, 33, 133
Recognition of rootstocks in the nursery, 130
Recording technique, 25
Red Spider, on fruit trees, 36, 40, 138
—— ———, on hops, 38, 42
—— ———, control, laboratory tests, 39
—— ——— ———, field trials, 36, 40
—— ———, predaceous insects of, 36, 138
Red Spiders, British, 38
" Renewal " system of pruning, 19
Root and green crops, acreage, 14
Rootstock, Malling Crab C, 126
———— effect on mineral content of leaves, 31
Rootstocks, anatomical studies, 18
————, for cordon culture, 23
————, for dessert apples, 118
————, for dwarf pyramid culture, 47, 123
————, for tree fruits, 17, 22
————, in Germany, 17
————, in relation to soil type, 17
————, new varieties, 17, 63
————, propagation from hardwood cuttings, 49, 79, 131
————, recognition in the nursery, 130
" Rubbery Wood " in apples, 18, 22

Sampling, 25, 26
Seed soaking, of cereals with nutrients, 85
Seeds hay, 14
Shoot/Root ratio in cuttings, 52
Short-term leys in fruit plantations, 22
Shot Hole Borer, 92
Silver Leaf, 12, 17
Size of fruit, estimation by sampling, 26
Small fruits, cropping, 12
——— ———, for interplanting among dessert apples, 120
——— ———, Ministry's Certification Schemes, 13
Soil applications for cure of deficiencies, 85
—— effect on behaviour of cuttings, 49
—— ——— on habit of cuttings, 79
—— moisture, 19
Spray application, influence of personal factor, 25, 32
—— damage on cover crops, 19
—— ——— on trees pruned by " Renewal " system, 19
—— induced fruit drop, 27

Spraying in bloom against Apple Scab, 32
———— Programme, 16
———— to control Bacterial Canker, 135, 136
———— to cure mineral deficiencies, 29, 30, 85
———— to reduce pre-harvest fruit drop, 27
Spring Usher, 93
Stem-builders resistant to Bacterial Canker, 134
Stem/Root ratio in cuttings, 81
Stool-beds, 13, 18
————, effect of winter frost on, 17
Storage, low temperature, of woolly aphid parasite, 142
Straw, application on black currants, 21
Strawing for frost damage prevention, 21
Strawberries, breeding, 21
————, certification, 21
————, cropping trials, 20
————, frost damage, 11
————, isolated nurseries, 21
————, prevention of frost damage to, 21
————, propagation, 21
Strawberry Aphids, 37
———— Aphid Survey, 37
———— ————, vaporized nicotine treatment, 37
———— Blossom Weevil, 37
———— Identification Key, 20, 23
———— insects, 37
———— irrigation trial, 21
———— Leaf Blotch, 34
———— nuclear stocks scheme, 21
———— Rhynchites, 37, 91
———— runners, production of, 14, 21
———— ————, certificates, 21
———— Tarsonemid Mite, 37, 95
———— variety trials, 20
———— Verticillium Wilt, 14, 32
———— virus diseases, 33
———— Yellow-edge, 33
Swards, 19, 23
Symptomless deficiencies, 84
Systems of planting dessert apples, 118

Tarsonemid Mite of Strawberry, 37, 95
Thinning of fruits, 19
Thiocyanates as ovicides, 39
Thiuram sulphides, as fungicides, 39
Top fruits, cropping, 11
Top: Root ratio of cover crops, 22
Trace element deficiencies, 29, 83
Trace elements, physiological effects, 89
Tomato trials in 1944, 22
Tydeman's Early Worcester apple, 121
———— Late Cox apple, 121

V Moth, 93
Variation in non-clonal walnut varieties, 67
———— studies, 25
Verticillium Wilt, 14, 32, 41
———— ——, resistant hop varieties, 101
Vegetative propagation by cuttings, 27, 49, 79, 96, 104, 128, 131
Vine Weevil, 93
Virus diseases, 32, 33, 133

Walnuts, 21, 67, 70
————, frost damage, 71
————, pollination, 72
————, rootstock effect, 67
————, variety collection, 70
————, variation in non-clonal varieties, 67
Weather conditions during 1945, 76
Wheat, mineral deficiencies in, 29, 83
Winter Moth, 94
——— pruning of pears, 54
Woolly Aphid, parasite of, 36, 142
———— ——, rootstocks immune from, 17

Zinc deficiency, 29, 84